January, 1958

The Mining Magazine

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CONTENTS

EDITORIAL

A FOURTH edition of Winiberg's " Metalliferous Mine Surveying " has been published this month by Mining Publications, Ltd., proprietors of THE MINING MAGAZINE. The new work has been revised and enlarged by Mr. R. C. A. Hooper, Lecturer in Mine Surveying at the School of Metalliferous Mining, Camborne, and now extends to over 400 pages. Among the additions and replacements made by the author of the new text mention may be made of triangulation adjustment, contouring, settings of planimeters, transformation of co-ordinates formula, vertical projection formula, and various methods of plan and layout control. It is hoped to publish an independent review in a subsequent issue of the MAGAZINE.

IT has been announced that, by action of the Board of Regents of the University of Minnesota on June 15, 1957, the Minnesota School of Mines and Metallurgy has been re-organized and now comprises the three divisions of Mineral Engineering, Metallurgical Engineering, and the Mines Experiment Station, Professor S. R. B. Cooke being the Head of the School. Physical Metallurgy has been transferred to the School of Chemistry, where it will function as the Department of Metallurgy, separate curricula being available in Metallurgical Engineering, Geological Engineering, Mining Engineering, and Geophysics (School of Mines and Metallurgy) and in Metallurgy (School of Chemistry).

NAMES appearing in the New Year Honours List that will be noticed by mining men include those of Mr. A. E. Crook, Principal Inspector, Mechanical Engineering, of the Mines Inspectorate, Mr. R. Ringham, Chairman East Midlands Division, N.C.B., and Mr. W. C. C. Rose, Assistant Secretary, Chief Scientist's Division, Ministry of Power, each of whom is made C.B.E., while an Honorary C.B.E. is conferred upon Mr. H. J. Hendricks, lately resident director and manager, Cyprus Mines Corporation. The O.B.E. goes to Mr. J. M. Watson, Director of National Resources, Somaliland, and W. D. Harverson, Commissioner (Mines and Geology), Kenya, and the M.B.E. to Mr. A. J. P. Coetzee, chief medical officer Rhokana Corporation, Ltd.

POSTGRADUATE courses have long been a prominent feature of the work of the Imperial College of Science and Technology, which now has the largest school of postgraduate workers in the United Kingdom. In the present session about a third of the 860 full-time postgraduate students are taking such courses. The College has just issued its advance programme for postgraduate work in the 1958–59 session and this shows that a considerable further expansion is planned.[1] Forty-one separate courses leading to a higher degree and/or to the Diploma of the Imperial College are available, of which 34 have already been accepted by the Department of Scientific and Industrial Research for the tenure of their Advanced Course Studentships. Prominent among the courses are those in branches of engineering—for example, in automatic control systems, nuclear power, gas-turbine technology, geology, mineral exploration, applied geophysics, pure geochemistry, and mining, including mining economics. The courses provide the opportunity for students, including many who have already spent a period in industry, to further their knowledge in a particular specialized field and at the same time to learn from experts their experiences of the application of this knowledge in industry.

British Overseas Mining Association

As will have been evident from the note on last year's progress report of the British Overseas Mining Association which appeared in the December issue taxation and the interpretation of the status of Overseas Trading Corporations are now its chief concerns. Speaking at the annual general meeting held last month the president of the Association, Mr. A. M. Baer, made further references to these matters. In respect of the taxation problem he said it had been their constant endeavour to obtain adequate recognition by the United Kingdom authorities of the special problems facing the British overseas mining industry in areas where competition with the mining industries of other countries was keen. Such countries with a more favourable tax " climate " were

[1] " Postgraduate Courses, 1958–59," price 1s. post free, from the Registrar, Prince Consort Road, London, S.W. 7.

often at an unfair advantage, Mr. Baer pointed out, and the lightening of the tax burden borne by British companies should, he thought, have already been recognized as as equitable adjustment of the unfair balance. He suggested, however, that while progress in this self-appointed task had been slow the Association's efforts had not been entirely unrewarded, since the provisions of recent legislation go " some way " towards meeting a few of the claims the Association has consistently advanced. " To that extent," he thought, " they may be regarded as the culmination of the unremitting efforts of our Taxation Committee, to which the industry is undoubtedly greatly indebted." This is, indeed, probably true, but, as the president went on to say, the overseas mining industry comprises a very complex structure, many types of company—such as, the mining finance houses and holding and co-ordinating companies responsible for the organization and financing of the greater part of modern mineral exploration and development—not at present qualifying for the benefits which will accrue to the overseas trading corporations. While the Association, said Mr. Baer, " understands the desire of the tax authorities to move cautiously with this new departure in U.K. tax legislation," it is to be hoped that the Government may yet find it possible to cater for those important sections of the overseas mining industry. To this end the claims of two such sections have been put forward in a letter which the Association has recently addressed to the Chancellor of the Exchequer.

The need for ensuring that the influx of young men offering themselves for training in such subjects as mining engineering, geology, and extractive metallurgy into the schools of mines and universities is mentioned in the report and in the December issue attention was drawn to the fact that a new scholarship scheme is being considered. This scheme, it can now be noted, has happily been accepted and a Central Scholarship Fund is to be set up. A number of the larger companies and groups of companies have already promised generous financial support and a general appeal is shortly to be issued to members of the Association inviting them to contribute. The Association has appointed a committee to consider details of the new scheme and an early announcement is expected. Here we can only say how heartily the scheme should be supported and how much we hope for its success.

Safety in Mines Research

In his introduction to the 35th Annual Report of the Safety in Mines Research Advisory Board, covering 1956, published early this month the director, Mr. H. T. Ramsay, points out that early in that year the Board was re-appointed and given new terms of reference. It is now asked to advise the Minister of Power on the general scope and organization of research and to report progress. The director emphasizes that safety research, constantly in progress, cannot be expected to yield easy answers to many problems as yet unsolved. It is felt, indeed, that in spite of the additional facilities it possesses in the new premises it now occupies the work of the Establishment becomes increasingly difficult. Difficulties, the director says, have been felt particularly in the fields of dust dispersal, methane migration, and coal-dust explosions and he acknowledges the help given by Professor Owen and his colleagues of the Department of the Mechanics of Fluids of Manchester University. Collaboration with all universities, he points out, is also assisted by research contracts on fundamental problems and during the year under review frictional ignition of gases, combustion of gas, and dust have been studied, while various aspects of rat-infestation of drift mines and the biochemical effects of silicic acid and fibrogenic dusts are also undergoing examination. On pneumoconiosis collaboration with Professor King, Professor Gough, and the Pneumoconiosis Research Unit at Cardiff remains active, while the efforts of private firms and various research associations are also appreciated.

The report under review mentions the work carried out at the International Conferences of Directors of Safety in Mines Research, the ninth of which was held in Heerlen (Holland) and Brussels during 1956. The object of such conferences, it is stated, is the comparison of researches in progress at institutes with responsibilities for mine safety and particular interest is usually taken in the fields of explosives and explosions, the latter covering both methane and coal dust. In recent years these conferences have increased in size and that referred to here included tours of the research and testing station (Central Proefstation) of the Dutch State Mines at Treebeck and of the Belgian research station (Institut National des Mines) at Paturages, as well as visits to several Dutch and Belgian

coal mines and to a Belgian explosives factory. The next (Tenth) International Conference is to be convened by Poland, the topics to be discussed including underground fires and explosions.

Outlook for Nickel

In his customary year-end review, Dr. John F. Thompson, chairman of the International Nickel Co. of Canada, Ltd., expresses the view that: " Barring any presently unforeseen large increases in defence demand it is expected that there will be more nickel available to the industries of the 'free world' in the coming year than was the case in 1957." He is of the opinion that the supply-demand situation will be in closer balance even if some supplies will continue to command premium prices. Dr. Thompson says that " in view of the announcement of the United States Government that it desires to divert to industry all nickel scheduled for stockpiling it is expected that the supply in that country will exceed the demand." It follows, therefore, that " creating larger markets in preparation for the time the above-mentioned nickel production capacity goal is realized in 1961 is a major task confronting all producers in the industry."

In the year that is past, particularly in the final quarter, " after many years of nickel shortages for civilian purposes" allocated nickel and metal from the " grey " market came into closer balance. Indeed, in the United States of America the supply exceeded the demand, the change being brought about by a record high " free world " production of nickel, sharply reduced demands for defence, and the United States Government's endeavour to divert nickel from the stockpile. Some nickel was also released from the United Kingdom's stockpiles, while world defence requirements were substantially lower than in 1956. In the year past nickel supplies have been estimated at 490,000,000 lb. for the " free world," as compared with the previous record of approximately 450,000,000 lb. in 1956 and 425,000,000 lb. in 1955. For the year deliveries by the several Canadian producers should reach a new high total of about 360,000,000 lb. representing approximately 75% of the supply. Of the balance available Cuba will account for about 9%; the United States, 4%, and New Caledonia, Japan, and others, 12%. International Nickel itself—" the world's largest nickel producer,"—operated at capacity in 1957 for the eighth consecutive year and the company's deliveries of nickel in all forms in 1957 will exceed 290,000,000 lb., or about 5,000,000 lb. above deliveries in the previous year.

Of developments in the past year Dr. Thompson, referring to his company's Manitoba project, points out that a recent major development has been the completion of the 30-mile railway spur linking the project's plant site area at Thompson with the Canadian National Railways' Hudson Bay line; this now provides year-round transportation for men, equipment, and supplies. At this site initial production is scheduled to start in 1960, with an annual nickel capacity of 75,000,000 lb., the programme involving an initial investment of $175,000,000, of which International Nickel's capital share will approximate $115,000,000. In combination with the progress under way at its operations in the Sudbury district the Manitoba development is expected to increase the company's annual nickel-producing capacity to 385,000,000 lb. in 1961. At the same time, the chairman said, " the past year saw the announcement of two other important projects which are aimed at increasing nickel production capacity in future years. Freeport Sulphur Company announced that it will produce 50,000,000 lb. of nickel annually from its deposits at Moa Bay, Cuba, and the French nickel company, Le Nickel, with mines on the island of New Caledonia, disclosed plans to increase its output to 50,000,000 lb. or more per year. Considering these programmes and those announced by other companies Dr. Thompson expects that " the annual total free world nickel-producing capacity in 1961 will approximate between 650,000,000 and 675,000,000 lb., with much of the increase government stimulated or sponsored. Included in the estimated 1961 total production capacity is the nickel output of the United States Government-owned plant at Nicaro, Cuba, which is understood to have increased its production facilities to 50,000,000 lb. annually, and also that of such Canadian producers as Falconbridge Nickel Mines, Ltd. and Sherritt Gordon Mines, Ltd., which have announced that they will increase their respective productions to 55,000,000 and 25,000,000 lb. annually." This is adequate comment, indeed, on a situation that has altered rapidly within the past year.

MONTHLY REVIEW

Introduction.—The marked falls in metal prices which occurred in the year just concluded appear now to have approached bottom as the effects of efforts to halt inflation begin to be felt. The differences within the Government recently exposed seem to have made but little impression on business confidence.

Transvaal.—The gold return figures for the Rand and O.F.S. mines for November show a production of 1,386,047 oz., making with 36,470 oz. from outside mines a total of 1,422,517 oz. for the month. The number of natives at work in the gold mines at the end of November was 332,723 as compared with 310,428 at October 30 last.

The table below shows dividends declared by the Rand mining companies for the past half-year. Figures for the three preceding half-years are added for comparison, the denomination of shares being £1 unless otherwise stated.

	1st half, 1956	2nd half, 1956	1st half, 1957	2nd half, 1957
	s. d.	s. d.	s. d.	s. d.
Blyvooruitzicht (2s. 6d.)	1 0	1 0	1 0	1 0
Brakpan (5s.)	0 4½	0 6	0 4½	0 4½
Buffelsfontein (10s.)	—	—	—	1 6
City Deep	—	0 6	0 6	0 6
Consolidated Main Reef	2 0	1 6	1 3	1 3
Consolidated Murchison (5s.)	5 0	7 6	3 9	1 9
Crown Mines (10s.)	3 0	2 0	1 0	1 3
Daggafontein (5s.)	2 9	2 9	2 6	2 9
Dominion Reefs (5s.)	1 3	1 3	1 3	1 6
Doornfontein (10s.)	—	—	0 6	1 0
Durban R'd'poort D'p (10s.)	1 3	1 6	1 6	1 6
East Champ d'Or (2s. 6d.)	0 3	0 7	0 3	0 4
East Daggafontein (10s.)	0 9	0 9	0 9	0 9
East Geduld (4s.)	2 0	2 3	2 0	2 0
East Rand Prop. (10s.)	2 0	2 6	2 3	2 3
Eastern Rand Ext. (5s.)	—	0 6	—	1 3
Eastern Transvaal (5s.)	0 4½	—	0 4½	—
Geduld Prop.	6 9	7 6	6 3	6 6
Government Areas (5s.)	0 3	0 3	—	—
Grootvlei Prop. (5s.)	1 1	1 4	1 1	1 3
Hartebeestfontein (10s.)	1 0	1 6	2 6	3 0
Libanon (10s.)	0 3½	0 3½	0 3½	0 3½
Luipaards Vlei (2s.)	0 9	0 10½	1 0	1 1
Marievale Consolidated (10s.)	1 0	1 3	1 0	1 3
Modderfontein East	1 0	2 0	1 0	0 9
New Pioneer Central Rand (5s.)	—	—	1 0	—
Rand Leases (10s.)	0 3	0 1½	0 1½	0 3
Randfontein	2 6	2 6	2 3	2 3
Rietfontein Cons. (5s.)	1 1	1 1	1 1	1 1
Robinson Deep, B (7s. 6d.)	0 3	0 6	0 6	0 9
Simmer and Jack (2s. 6d.)	0 5	0 5	0 5	0 5
South African Land (3s. 6d.)	1 6	1 6	1 6	1 6
South Roodepoort M.R. (10s.)	1 1½	1 1½	1 1½	1 1½
Southern Van Ryn	—	0 2	—	0 5
Springs Mines (5s.)	0 2¼	0 3	—	0 4½
Stilfontein (5s.)	0 6	0 6	1 0	1 10½
Sub Nigel (10s.)	3 0	2 4½	1 9	1 6
Transvaal G.M.E. (1s. 3d.)	0 5	0 10	—	—
Vaal Reefs (5s.)	—	1 0	1 3	2 3
Venterspost (10s.)	0 9	0 10½	0 10½	0 10½
Village Main Reef (1s. 3d.)	0 1½	0 1	0 1	0 1
Vlakfontein (10s.)	0 9	0 10	0 10	0 11
Vogelstruisbult (10s.)	1 8	1 6	1 4	1 2
West Driefontein (10s.)	2 9	3 0	3 3	3 6
West Rand, Ord. (10s.)	1 9	2 3	2 0	2 3
Western Reefs (5s.)	1 3	1 3	1 3	1 3

The reduction in the capital of MODDERFONTEIN GOLD MINING approved at the meeting held in Johannesburg last November has now been confirmed by the Supreme Court. The company's capital is now, therefore, £350,000 in 2s. 6d. shares.

At an extraordinary meeting of GOVERNMENT GOLD MINING AREAS (MODDERFONTEIN) to be held in Johannesburg on January 23 it is to be proposed that the capital of the company be reduced to £1,260,000 in 4s. 6d. shares by a return of 6d. a share on the present 5s. units.

Earlier this month shareholders of VAAL REEFS EXPLORATION AND MINING were informed that the ANGLO AMERICAN CORPORATION OF SOUTH AFRICA had exercised its right to subscribe for 500,000 shares of 5s. each at 35s. per share. The issued capital of the company has accordingly been increased to £2,625,000.

The statement of the chairman of KLERKSDORP CONSOLIDATED at the annual meeting held last month reveals that the company is at present engaged in important new negotiations in respect of its extensive reserves of uranium-bearing ore. Present discussions are said to be supported by " most helpful cooperation from the South African authorities."

A circular to shareholders of WELGEDACHT EXPLORATION issued last month announces that a provisional agreement has been concluded with UTRECHT COLLIERIES, LTD., for the purchase of its undertaking as a going concern. The purchase price is £319,739 14s. 8d., of which £139,739 14s. 8d. is payable on the date of taking over. The balance of £180,000 is payable on or before December 31, 1959. Shareholders' approval was sought at an extraordinary meeting held on January 10.

The accounts of WITBANK COLLIERY for the year to August 31 last show a profit of £273,123 and a total of £579,661 available, of which dividends equal to 7s. 6d. a share require £144,375. In the year 1,693,067 tons of coal was despatched from the mine, 1,406,425 tons of this coming from the Wolvekrans section.

Orange Free State.—The report of FREE STATE GEDULD for the year ended September 30 last shows a surplus of £1,819,388, of which a first dividend equal to 1s. a share required £439,938. In the year 646,000 tons

of ore was milled and 380,075 oz. of gold recovered. Ore reserves at the end of the year are given as 1,899,000 tons averaging 18·74 dwt. per ton. The present milling capacity is already 125,000 tons per month, but work is to be put in hand during the coming year to increase the capacity of the treatment section of the plant from 100,000 tons per month to 125,000 tons per month. The grade of uranium oxide disclosed in development sampling thus far, it is stated, does not indicate that a profit can be derived from this source.

The accounts of WELKOM GOLD MINING for the year to September 30 last show a profit of £652,007 and £852,074 for appropriation, of which a first dividend equal to 3d. a share requires £153,125. In the year 1,024,000 tons of ore milled yielded 267,842 oz. of gold, while 100,147 lb. of uranium oxide was also obtained. Ore reserves are estimated as 3,471,000 tons averaging 6·52 dwt. in gold and 0·315 lb. uranium oxide over 46·31 in. The report states that the results obtained from the experimental pilot plant for desalting underground mine water, operated in Welkom by the Council for Scientific and Industrial Research in co-operation with mining companies in the Orange Free State, have been sufficiently encouraging to warrant further experiments on a far larger scale.

PRESIDENT BRAND GOLD MINING reports a surplus of £5,245,685 for the year to September 30 last, dividends equal to 5s. a share requiring £3,250,000. In the year 581,373 oz. of gold and 211,218 lb. of uranium oxide came from 764,500 tons of ore milled. At September 30 last ore reserves were estimated as 3,043,000 tons averaging 17·63 dwt. in gold and 0·347 lb. uranium oxide per ton.

The operations of PRESIDENT STEYN GOLD MINING for the year to September 30 last resulted in a profit of £2,848,819, the accounts showing the same amount available, of which dividends equal to 2s. 9d. a share require £1,787,500. The report shows that 1,098,000 tons of ore was milled, yielding 420,625 oz. of gold and 285,350 lb. uranium oxide. The 3,927,000 tons of ore in reserve average 8·81 dwt. in gold and 0·367 lb. uranium oxide per ton.

In his review of operations at LORAINE GOLD MINES for the year ended September 30 last, when there was a loss of £66,193 on gold production, the chairman says that "while there is justification for continuing operations on the present scale for the time being, in the hope that better development values will be obtained, it is not possible to lay down any long-term policy in regard to future mining operations."

The appropriation account of WESTERN HOLDINGS for the year ended September 30 last shows a surplus of £3,678,074, of which dividends totalling 5s. a share require £1,874,094. In the year 1,144,000 tons of ore crushed yielded 537,974 oz. of gold. Ore reserves are given as 3,930,000 tons averaging 13·99 dwt. in gold per ton.

Diamonds.—It has been announced that sales of diamonds in 1957 through the Central Selling Organization totalled £76,772,112, of which £52,818,096 represents gem stones.

Northern Rhodesia.—Shareholders of KANSANSHI COPPER MINING were informed last month that before the mine was flooded it was producing about 400 long tons per month of copper in concentrates and consideration was being given to increasing production. However, at present copper prices, it is stated, there is nothing to be gained by re-opening the mine for the extraction of sulphide reserves only, so that plans for leaching the oxide ores are now the subject of close investigation. "These studies are being pursued as energetically as possible, but the consulting engineers expect that it will be at least six months before they are able to make any report."

Nigeria.—The mineral production of Nigeria for November last included 1,306 tons of cassiterite, 192 tons of columbite, 100 tons of thorite, and 7 tons of monazite.

JANTAR NIGERIA reports a profit of £42,774 for the year ended September 30 last, of which £30,000 has been placed to reserve. The company's output for the year included 279½ tons of cassiterite and 255½ tons of columbite.

Tanganyika.—Addressing the annual general meeting of TANGANYIKA DIAMOND AND GOLD DEVELOPMENT held in Johannesburg recently the chairman said the modifications carried out to the treatment plant in the year past had enabled the management to treat, together with the virgin gravels, large quantities both of old pan tailings and oversize discarded in previous years, the resulting recoveries indicating that certain of the old tailings dumps may be regarded as potential ore reserves.

In the September quarter GEITA GOLD MINING milled 71,760 tons of ore and recovered 10,698 oz. of gold. Lack of standby power has tended seriously to affect opera-

tions, but it is hoped that this difficulty will soon be overcome.

Australia.—At the recent annual meeting of Lake View and Star, Ltd., the chairman said that in the year to June 30 last development was principally in the western group of mines where 5,858·5 ft. of payable driving on the various lode channels compared with 6,293 ft. for the previous year. Payability in the western section, however, improved from 55·7% in the previous year to 59·9%, while payability in the eastern section was 54·0%, compared with 64·3%. Ore reserves on July 1, 1957, amounted to 3,577,000 tons of an average grade of 4·78 dwt. per ton.

New Guinea.—At the annual meeting of Bulolo Gold Dredging held in Vancouver recently the chairman said that the profit for the year ended May 31, 1957, was $966,505 compared with $396,960 for the previous year. Dredge No. 4 was permanently closed down on May 25, 1957, and dredge No. 5 only will be operating during the coming year, recovery to October 13 averaging 19·58 cents per cu. yd. These results exceed the estimates, but the dredge may have to traverse low-value ground later to reach reserves formerly allocated to dredge No. 7 and every effort is to be made to extend profitable operations. It is estimated that the profit from dredging and sluicing operations for the current year will be approximately $250,000.

Burma.—Burma Corporation (1951) (incorporated in Burma and jointly owned by Burma Mines and the Union Government) issued its accounts for the year ended June 30, 1957, in Rangoon on December 30. These disclose a net profit after deduction of taxation of K.34,29,783 (£257,234) which compares with K.70,14,755 (£526,107) for the previous year. Provision is made for a dividend of 5¼% free of Burma taxation.

Speaking at the annual meeting of Anglo-Burma Tin held in London last month the chairman said that much depended on the progress of the joint venture company and that it was hoped that the plant would continue in operation. For the financial year to September 30, 1957, production amounted to approximately 129 tons, approximately 92 tons of which was won during the final three months of July to September when the plant was working.

United Kingdom.—Last month the directors of English China Clays, Ltd., announced that contracts had been exchanged for the acquisition of a number of quarry companies carrying on business principally in Devon and Cornwall. The consideration for the acquisition consists of 200,000 5½% preference shares and 525,000 ordinary shares (all of £1 each credited as fully paid) of English China Clays and £100,000 in cash. Further particulars are to be circulated. In connexion with the acquisition the directors have stated that the profits of English China Clays and its subsidiaries before taxation earned during the year ended September 30, 1957, are not less than those earned during the previous year.

Apex (Trinidad) Oilfields.—The accounts of Apex (Trinidad) Oilfields for the year ended September 30 last show a profit of £773,817 and £1,236,484 available, of which dividends equal to 2s. a stock unit, free of tax, require £440,000. Shareholders are informed that a participation of 25% has been taken in Canpet Exploration, Ltd., which is carrying out a programme of acquiring and developing oil properties in Canada, while Inland Revenue approval has been given for recognition of the company as an overseas trading corporation as from April 6, 1957.

Rio Tinto Mining Co. of Canada.—It has recently been announced that the Rio Tinto Mining Co. of Canada, Ltd., and Dow Chemical of Canada, Ltd., have jointly formed a new company—Rio Tinto-Dow, Ltd.—whose initial purpose will be to concentrate on the production of thorium and rare earths from by-product materials of three uranium mining companies in the Blind River area, Canada, managed by the Rio Tinto group. Shareholders of the new company will be Dow Chemical of Canada and the Rio Tinto Mining Company of Canada, together with the mining companies concerned—namely, Algom Uranium Mines, Northspan Uranium Mines, and Milliken Lake Uranium Mines. It is pointed out that Dow Canada, a wholly-owned subsidiary of the Dow Chemical Company, are manufacturers of basic chemicals and Rio Tinto Canada is a subsidiary of the Rio Tinto Company, Ltd.

Tanganyika Concessions.—At the annual meeting of Tanganyika Concessions, Ltd., to be held in Salisbury, Southern Rhodesia, later this month it is to be proposed that 3,821,412 of the unissued £1 shares be each subdivided into two ordinary 10s. shares. It is proposed also to capitalize the sum of £3,821,412, comprising the capital reserve and profit unappropriated and to issue the

new 10s. shares to existing holders in the proportion of one new share to each nominal 10s. ordinary stock held. The company's accounts for the year to July 31 last show a profit of £4,309,796 and £6,600,329 available, of which £3,787,412 was required for dividends, equal 9s. 6d. on the ordinary stock.

Consolidated Gold Fields of South Africa, Ltd.—At the annual general meeting of the Consolidated Gold Fields of South Africa held in London last month the chairman said that the net profits of the operating company and retained by its subsidiaries amounted to £535,000. Of the South African gold-mining industry he said that good progress was maintained. In the year to June 30 last there was no significant change in the tonnage of ore treated but the yield of gold had increased by more than 1,250,000 oz. to just over 16,000,000 oz. In regard to uranium he said that 26 companies were now sending tailings for re-treatment in 16 extraction plants, resulting in a production of 5,007 tons of uranium oxide in the year under review.

Turner and Newall, Ltd.—The report of Turner and Newall, Ltd., for the year ended September 30 last shows a profit of £4,661,600 of which dividends equal to 15% on the ordinary stock required £1,946,095. In his statement accompanying the report and accounts the chairman speaking of the African mining companies said studies being made with a view to expanding the scale of operations at some of the existing mines in Southern Africa are continuing satisfactorily. It is still intended to proceed with expansion plans although the timing of their application may be affected to some extent by a lessening in demand for asbestos fibres throughout the world. The Canadian company—Bell Asbestos Mines, Ltd.—of Thetford Mines, Quebec, continued to produce on a basis which is very close to maximum milling capacity; quality was well maintained and, in the case of some grades, slightly improved.

DIVIDENDS DECLARED

*Interim. †Final.
(Less Tax unless otherwise stated.)

African and European Investment.—Pref. 3%, payable Feb. 15.

African Land and Investment.—Pref. 3%, payable Jan. 10.

†**Apex Mines.**—3s., payable Feb. 6.

†**Associated Manganese Mines of South Africa.**—50%, payable Feb. 6.

***Ayer Hitam Tin Dredging.**—3d., payable Jan. 23.

Beralt Tin and Wolfram.—Special dividend 2s., payable Jan. 22.

†**Burma Corporation (1951).**—5¼d., free of Burma tax.

***Cape Asbestos Co.**—5%, payable Jan. 25.

***Central South African Lands and Mines.**—10%, payable Feb. 13.

†**Consolidated Diamond Mines of South-West Africa.**—Pref. 4½d., Ord. 10s., payable Feb. 15.

De Beers Consolidated Mines.—Pref. 10s., payable Jan. 28.

***Gopeng Consolidated.**—9d., payable Jan. 10.

†**Huelva Copper and Sulphur Mines.**—Pref. 0·84d., Ord. 10·8d., payable Jan. 21.

***Idris Hydraulic Tin.**—9d., payable Jan. 24.

***Kepong Dredging.**—4½d., payable Jan. 10.

***Kinta Tin Mines.**—1s. 3d., payable Dec. 31.

***Malayan Tin Dredging.**—4d., payable Jan. 31.

Middle Witwatersrand.—6d.

***Nchanga Consolidated Copper Mines.**—4s. 9·6d., payable Feb. 5.

***Powell Duffryn.**—6%, payable Feb. 25.

***Puket Tin Dredging.**—2·4d., payable Jan. 7.

Rambutan.—*1s. and *1s., payable Dec. 17.

***Rand Mines.**—3s., payable Feb. 6.

***Rhodesia Broken Hill.**—6·4d., payable Feb. 5.

***Southern Malayan Tin Dredging.**—4d., payable Jan. 29.

***Sungei Besi Mines.**—7·2d., payable Jan. 21.

***Tanjong Tin Dredging.**—1s. 3d., payable Dec. 31.

***Tekka.**—6d., payable Jan. 17.

***Transvaal Consolidated Land.**—2s., payable Feb. 6.

***Tronoh Mines.**—6d., payable Jan. 16.

West Witwatersrand Areas.—1s. 7½d., payable Feb. 16.

Zambesia Exploring.—6%, payable Feb. 20.

METAL PRICES

Jan. 8.

Aluminium, Antimony, and Nickel per long ton; Chromium per lb.; Platinum per standard oz.; Gold and Silver per fine oz.; Wolfram per unit.

	£	s.	d
Aluminium (Home)	197	0	0
Antimony (Eng. 99%)	190	0	0
Chromium (98%-99%)		7	2
Nickel (Home)	600	0	0
Platinum (Refined)	28	10	0
Silver		6	5⅛
Gold	12	9	0¼
Wolfram (U.K.)		—	
(World)	4	12	6

Tin, Copper, Lead, Zinc } See Table, p. 48.

Flotation: The Art of Utilizing Modifying Agents[1]

Samuel P. Moyer[2]

A review of the tools available to the present day mineral-dressing engineer.

Introduction

Chemical flotation, or the use of modern chemical flotation promoters as they are known to-day, is about 36 to 37 years old and it is interesting to observe that the flotation operations throughout the world have been using the same flotation promoters for almost the entire period. During this time steady progress has been made in improving selective flotation practice. This improved selectivity has been brought about in general by the judicious application of old and new modifying agents and not by the discovery of new types of flotation promoters.

Modern flotation practice probably depends as much on the combination of modifying agents that are used for a particular operation as it does on the choice of promoters. The choice of a frother is quite often coincidental and more often than not is dependent on the olfactory sensitivity of the particular mill superintendent. This is not to say that the choice of the correct promoter or frother to do any particular job is not important, for it is. What is implied is that the multiple choice and use of any combination of the vast array of modifying agents currently used in to-day's flotation practice could easily result in minimizing the effect of the correct choice of the promoter and frother.

To those uninitiated in the art of flotation it is difficult to explain why the industry does not have at its disposal a series of flotation promoters each designed to do a specific job—such as, a specific promoter for the flotation of sphalerite that would float sphalerite only, or a specific promoter for the flotation of arsenopyrite that would float only this mineral. It is true, however, that there are certain types of promoter reagents available which exhibit specificity towards certain groups of minerals. For example, the *Aerofloat*[1] promoters are more selective in their action on certain sulphides than are the xanthates. Also, the cationic type promoters—such as, the long-chain alkyl amines—are specific in their action toward silica and silicates. While it is true that the development of a new series of promoters designed to promote specific minerals would take much of the art out of flotation practice and would, perhaps, in time, result in a new science—the science of flotation—it should be realized that the development of the desired specific promoters can only be achieved by study of the fundamentals of flotation.

While the many scientists in research laboratories throughout the world continue to make progress in their basic studies of flotation and in the development of new and better flotation chemicals, it is in the practical application of the available promoters, frothers, and modifying agents that the artistry of the flotation engineer becomes essential.

Modifying Agents

Modifying agents change the surface of minerals so as to modify their amenability to flotation with a particular promoter-frother combination. Modifiers may be activators for slow-floating minerals, depressants for sulphide minerals in differential flotation operations designed to separate one sulphide from another, inhibitors of the flotation of gangue minerals, pH or alkalinity regulators, and the like.

Modifiers generally used in the flotation of sulphide minerals are:

(*a*) Acids and alkalies for pH adjustment and control.

[1] A paper presented at a Pacific North-West Regional Conference of the American Institute of Mining and Metallurgical Engineers in April, 1957.

[2] Field Representative, Mining Chemicals Department, American Cyanamid Company, Spokane, Washington.

[1] Reg. U.S. Pat. Off.

(*b*) Cyanides, usually sodium or *Aero*[1] Brand Cyanide, as depressants for zinc and iron minerals in the differential flotation of lead-zinc-iron ores, but also used to separate copper sulphides from galena, copper sulphides from pyrite, and nickel sulphides from copper sulphides.

(*c*) Copper sulphate, as an activator for sphalerite and other sulphide minerals.

(*d*) Lime, as a depressant for pyrite in the treatment of copper ores, especially those ores in which the copper mineral is sensitive to the presence of cyanide. Lime is also used as an activator for certain copper minerals.

(*e*) Dextrine as a depressant for carbon and graphitic material in sulphide flotation ; also used to depress talcose and micaceous minerals.

(*f*) Organic dyes as depressants for carbon and certain insolubles.

(*g*) Sodium sulphide as a sulphidizing agent for oxidized minerals—such as, lead carbonate.

(*h*) Zinc sulphate as a depressants for zinc minerals in the differential flotation of lead-zinc ores. Cyanide is generally used with zinc sulphate for this purpose.

(*i*) A host of other modifying agents—such as, the alkaline silicates, sodium hydroxide, alkaline phosphates, ferro and ferricyanides, sulphur dioxide, sodium sulphite, calcium sulphite, lead acetate, chromates, ammonium-zinc cyanide, calcium-zinc cyanide, complex copper cyanide, permanganate, quebracho, starch, glue, alkaline fluorides, etc.

The Baffling Use of Modifying Agents

As an example of the baffling and sometimes incredulous use of modifying agents the flotation of a "typical" ore containing galena, sphalerite, pyrite, and pyrrhotite, with the usual mixture of siliceous gangue minerals or a dolomitic gangue might be examined. A questionnaire on how to handle this problem sent to a dozen mill superintendents or flotation engineers throughout the country, could easily elicit a dozen different solutions. Pity the plight of the professor of mineral dressing who has to teach this complex subject in the short time allotted to him.

In considering the stated problem there are three obvious possibilities :

(1) Differential flotation of the lead, zinc, and iron minerals, and of course any of the three could be floated first, second, or third, but for the purpose of this example let it be assumed that the usual practice is followed and that the lead is to be floated first, the zinc second, and the iron last.

(2) Bulk flotation of the lead and zinc minerals followed by flotation of the iron, with the lead and zinc separated later by flotation.

(3) Bulk flotation of the lead, zinc, and iron minerals, followed by subsequent separation of the three minerals by flotation.

It may be of interest to know that all three of the stated possibilities are currently being used or have been used in recent years at large flotation operations in the Western States.

In examining only the first possibility, first flotation of the lead and how it can best be accomplished should be considered, ignoring for the time being the determination of the proper promoter-frother combination, not because it is unimportant, but because the choice of the promoter-frother is quite often dependent upon the modifying agents that the particular mill superintendent or flotation engineer has decided he will use. The decision of this particular official to use certain modifying agents usually is a reflection of his past experience ; his selection may not always be the optimum for the particular ore. Strange as it may seem, an unwise choice of modifying agents or even of the promoter-frother combination does not always result in inferior metallurgy, although it is a definite possibility, but almost always contributes toward a higher reagent cost per ton of ore than is necessary.

The modifying agents most commonly used for selective flotation of the lead are : Soda ash, lime, either sodium or *Aero* Brand cyanide and zinc sulphate. Among the other modifying agents less commonly used to aid the selective flotation of lead are : Sodium silicate, zinc sulphite, calcium sulphite, dextrines, organic dyes, sodium hydroxide, alkaline phosphates, complex zinc cyanides, and many others.

Soda ash is generally preferred for alkalinity control and many operators claim that alkalinity of the ore pulp in the low range above neutral, somewhere in the pH range of 7·2 to 7·8, is optimum and that pH control is vital. Other operations, where the natural pH of the ore slurry is 8·0 to 8·5, use a half pound or more of soda ash per ton

[1] Reg. U.S. Pat. Off.

of ore and claim that pH control is of no value, since the use of soda ash does not have any measurable effect on the pH of the pulp. They claim, however, that without the use of soda ash the selectivity of the lead flotation is poor. Other operations use larger quantities of soda ash and run the pH of their ore slurry up to about 9·0, using pH measurement for operating control. Obviously the use of soda ash plays several different roles as an aid to the selective flotation of lead, but most important is the fact that there is no general rule to follow for the use of even this one modifying agent.

Lime is also used at many operations for pH or alkalinity control to aid the selective flotation of lead, even though many mill superintendents and flotation engineers insist that the use of lime in the lead circuit is one of the worst things that can happen to any self-respecting piece of galena. It is claimed by some that the use of lime in any form in the lead circuit results in poor selectivity; other operators claim that a small amount of lime is sometimes beneficial, while others find that only by the use of relatively large quantities of lime, even to the saturation point, can selectivity of the lead circuit be maintained. Control of the lime circuit is either by pH measurement or titration. Here again it is found that there is no general rule for the use of lime and it is interesting to observe that for such a simple thing as alkalinity control to aid the flotation of galena there are such divergent opinions.

Cyanide, either *Aero* brand cyanide or sodium, quite often in conjunction with zinc sulphate, is used in the lead circuit as an aid to the selective flotation of lead. The quantities of each used generally have no direct bearing on the amount of zinc present in the ore or on any other measurable ore quality. Sometimes either cyanide or zinc sulphate will be omitted and sometimes neither one will be found necessary. Here again it is found that there are no set rules for the use of modifying agents for such a simple thing as the selective flotation of galena.

Without considering the possible use of any of the other modifying agents sometimes used to aid the selective flotation of lead, it can be seen that the possible number of combinations that could be used to accomplish the particular job would be tremendous if all of them were to be investigated, especially when it is realized that the choice of the correct promoter and frother is also of utmost importance with any particular combination of modifying agents.

The correct choice and quantity of modifying agents, as well as promoters, for the subsequent flotation of zinc will depend, to some extent at least, upon the various reagents that were used in the lead circuit. For instance, it is sometimes difficult to maintain a selective flotation of zinc without outrageous reagent costs because of the carry-through of a non-selective promoter from the lead circuit. From the writer's own experience his first choice of a promoter for the selective flotation of lead in a soda ash circuit would be *Aerofloat* 31 promoter, while in a lime circuit it would be *Aerofloat* 242 promoter. Of course other promoters should always be investigated, especially to determine their effect on the subsequent selective flotation of zinc.

The modifying agents generally used for the selective flotation of zinc are lime and copper sulphate. While it may not seem that these two reagents would offer much in the way of variables, here again it must be realized that the choice of the promoter will not only affect the quantities of lime and copper sulphate required but will affect the points of addition of the lime, the copper sulphate, and the promoter. Generally, if a xanthate is used for promotion of the zinc, close control must be exercised to ensure elimination of the iron minerals although a conditioner ahead of zinc flotation may not be necessary. If one of the dry *Aerofloat* promoters is used optimum results are usually obtained by employing a conditioning period, with the copper sulphate and *Aerofloat* promoter added to the conditioner and the lime, if any is used, added to the last cleaning operation. *Sodium Aerofloat* promoter is perhaps the most selective for the flotation of sphalerite from pyrite and pyrrhotite.

For the recovery of the iron usually a strong non-selective promoter such as a xanthate is used, but one of the liquid *Aerofloat* promoters or a combination of *Aero* promoter 404 and xanthate can be used for this purpose, providing the pH of the pulp has been lowered by the addition of sulphuric acid, or more copper sulphate used. The iron minerals can sometimes also be floated quite easily, using sodium hydroxide as a modifying agent.

The foregoing description of the baffling uses of modifying agents normally used in the flotation of a " typical " lead-zinc-iron

ore should demonstrate to some degree the variables encountered in the solution of relatively simple flotation problems and the important part that modifying agents play. For the many successful and diversified operations throughout the country credit should be reflected on the mill superintendents and flotation engineers—the artists among scientists who are doing a remarkable job with the unscientific tools at their disposal.

Other Factors Influencing the Use of Modifying Agents

There are many other factors that influence the art of flotation and the part that modifying agents play in the successful selective flotation of minerals of complex ores. As always, there are no set rules to be guided by and the successful solution of the problems depend upon the ingenuity of the operating engineers. For this reason flotation will possibly always be considered as an art and never as a science.

First and foremost of these is the constant, and sometimes almost imperceptible, changes in both the physical and chemical characteristics of the ore itself. Sometimes a mill is required to treat by flotation two or more ores simultaneously, from different orebodies and in varying degrees of tonnage mixture, whose only similar physical and chemical properties that can be determined are that they all have the same metal content. This constant change in ore characteristics is what has led many a harried mill superintendent or flotation engineer to exclaim : " You don't have to be crazy to do this kind of work, but sometimes it helps."

Trace elements in the minerals themselves often change their normal floatability. Minor copper values in an otherwise respectable lead-zinc ore often lead to complex flotation circuits. Changes from hot summer ore pulps to cold winter pulps often result in changes in the relative floatability of lead and zinc minerals. Soluble salts in mill waters and in ores often present problems and many require modifying agents to counteract their ill-effects.

The problems posed by these and other variables are usually solved essentially by the proper use of modifying agents, used conjointly of course, with intelligent application of the proper promoter-frother combination.

Applications of Certain Modifying Agents

In an article of this scope it is impossible to do more than mention a few of the very large number of applications of modifying agents. Much could be written, for example, regarding the role of cyanide in the selective flotation of copper sulphides from pyrite and pyrrhotite ; the use of starch and sulphur dioxide for separating copper and lead sulphides ; the importance of soda ash and sodium silicate in the selective flotation of scheelite, etc. However, it is hoped that the following discussions will serve to illustrate some of the more interesting applications of modifying agents for certain specific separations.

Effect of Complex Copper Cyanide

Perhaps the least known but most widely used modifying agent to-day is that which is caused by the reaction between copper sulphate and cyanide. The complex copper cyanide plays a dual role in many differential lead-zinc-iron flotation circuits, causing depression of iron minerals while at the same time activating sphalerite. Many a mill operator has become aware of the effect of this complex modifying agent while attempting to find out why the zinc flotation circuit suddenly showed poor recovery of zinc and a high contamination with iron. In attempting to correct this condition many operators were surprised to find that the cyanide feeder ahead of the lead circuit was not feeding cyanide and that when feeding of cyanide was resumed normal activation of zinc and depression of iron ensued. In spite of the fact that this does not make sense to many mill operators, who have been told that cyanide is used for the purpose of depressing zinc in the lead circuit, experimentation by the mill operator has usually demonstrated the necessity for having cyanide available in the circuit to react with the copper sulphate to form the desired complex.

Some concentrators in the Pacific northwest of the United States add cyanide to the zinc flotation circuit specifically to form this complex copper cyanide. At a large copper-zinc concentrator where the use of any quantity of cyanide in the copper circuit depresses the copper mineral cyanide is added side by side with copper sulphate ahead of the zinc circuit to activate the sphalerite selectively. Equally good results are obtained by mixing the cyanide and

copper sulphate together before adding them to the circuit. At another large lead-zinc concentrator in the Pacific Northwest cyanide is also used ahead of zinc flotation to increase the recovery of zinc.

Laboratory tests on silver ores have shown that the complex copper cyanide will activate silver minerals while depressing pyrite and pyrrhotite, although cyanide itself is generally considered to be a depressant for silver minerals.

Extensive laboratory and pilot-plant testing on a copper-lead-zinc ore containing much pyrite, where the normal mill operation produced a bulk concentrate of the copper, lead, and zinc using large quantites of lime (8 lb. to 12 lb. per ton of ore) to depress the pyrite, showed that the use of relatively small quantities of cyanide and copper sulphate to form the complex copper cyanide (roughly 0·25 lb. and 0·80 lb. respectively) in a neutral circuit, no lime used, produced equally good results but with an indicated saving in reagent costs. The laboratory and pilot-plant testing on this ore indicated that conditioning for at least ten minutes with the cyanide, copper sulphate, and promoter ahead of flotation was necessary. *Aerofloat* 31 promoter was found to be the most effective for use in conjunction with the complex copper cyanide on this particular ore.

Unusual Effects of Copper Sulphate and Lime

Although copper sulphate and lime are commonly used at a great number of operations as modifying agents, the copper sulphate is normally used as an activator and the lime used for alkalinity control. An unusual use for these two common modifying agents is in the separation of chalcopyrite and sphalerite either from an ore or bulk flotation concentrate. The usual procedure for the separation of these two minerals is to float the copper first followed by flotation of the zinc. This separation is often a difficult one to make because the sphalerite usually begins to float at the scavenger end of the copper circuit. It is possible to isolate this scavenger copper-zinc product for special treatment. The procedure is as follows :—

Condition the scavenger flotation product, adjusting the alkalinity of the pulp with lime to the point where the chalcopyrite floats most readily. This will vary with different chalcopyrite ores. Then condition the pulp for ten minutes with about 5 lb. of copper sulphate per ton of feed. This addition of copper sulphate will generally result in positive depression of the chalcopyrite and, at the same time, activation of the sphalerite. Strange as it may seem this technique appears to work only when the copper mineral is chalcopyrite. Reactivation of the chalcopyrite can be accomplished by the addition of a small amount of lime. Selective promoters such as the dry *Aerofloat* promoters should be used in this type of copper-zinc separation.

Effect of Modifying Agents to Produce Arsenopyrite Concentrate

To produce an arsenopyrite concentrate from an ore containing arsenopyrite, pyrite, and pyrrhotite is difficult—by flotation or by any other means. Available information indicates that it is not being accomplished satisfactorily at any operation at the present time. However, there are several modifying agents that show up well in the flotation laboratory to accomplish this difficult separation and which should be investigated by those faced with this problem.

The use of permanganate in the " Separation of Pyrite, Arsenopyrite, and Pyrrhotite by Flotation," is explained in the U.S. Patent No. 2,342,277 by Earl C. Herkenhoff, assignor to American Cyanamid Company. In substance the process involves conditioning the ore pulp with a small amount of copper sulphate and soda ash to bring the pulp to about pH 9·4 and floating a bulk pyrite, arsenopyrite, pyrrhotite concentrate with *Aerofloat* 15 promoter and *Aero* xanthate 343. The bulk concentrate is refloated using potassium permanganate (0·01 to 0·02 lb./ton of ore) to depress the pyrrhotite while floating the pyrite and arsenopyrite. The pyrite-arsenopyrite concentrate is again subjected to flotation using sufficient permanganate (about 0·06 lb./ton of ore) to depress the arsenopyrite while floating the pyrite. Typical metallurgical results of this procedure are set out in Table 1. A high degree of concentration of arsenopyrite was obtained, 84 to 1, and the pyrite concentration was even higher, amounting to 196 to 1.

Table 1

Product.	% *Weight.*	*Assays,* % *Arsenic.*
Head	100·00	0·24
Pyrite concentrate	0·51	0·33
Arsenic concentrate	1·13	18·10
Cleaner tailing or pyrrhotite concentrate	3·59	0·37
Rougher tailing	94·71	0·015

Table 2

Product.	*% Wt.*	*Assays.* *% Cu*	*% Pb*	*% Zn*	*Distribution.* *% Cu*	*% Pb*	*% Zn*
Lead conc.	74·8	3·4	71·4	4·6	23·1	99·1	53·3
Copper conc.	25·2	33·6	2·0	12·0	76·9	0·9	46·7
Heads (calc.)	100·0	11·0	53·9	6·5	100·0	100·0	100·0

Reagents (lb./ton).	*Pb Rougher.*	*Pb Cleaner.*	*Pb Recleaner.*
Ammonium-zinc cyanide	7·0	1·5	1·4
Xanthate	0·02	nil	nil
Pine oil	as needed	as needed	as needed

A blank test which followed the same sequence but omitted the permanganate conditioning gave an arsenopyrite concentrate having only 1·17% of arsenic, more than 92% of the arsenopyrite remaining in the pyrite concentrate.

Use of the complex copper cyanide as a modifying agent to accomplish the selective flotation of arsenopyrite from pyrite and pyrrhotite using *Aerofloat* 31 promoter has also shown a good deal of promise in laboratory testing.

Effect of Ammonium Zinc Cyanide in Copper-Lead Separations

Considerable testing work was carried out several years ago in the pilot plant at a large concentrator to determine the effect of ammonium zinc cyanide as a modifying agent in the separation of the copper and lead in a flotation concentrate. Typical results from one of these pilot-plant runs are given in Table 2.

Although pilot-plant results were extremely encouraging copper-lead separation has not been incorporated into this plant flow scheme. It was found that the resulting copper concentrates contained arsenic (principally as tennantite) which would have involved a very high penalty at a copper smelter. Although shipment of bulk copper-lead concentrates to a lead smelter involves a considerable loss in payment for copper, the overall picture offers little incentive for making the copper-lead separation using 7 lb. to 9 lb. of ammonium-zinc cyanide per ton of bulk concentrates. Furthermore, the copper content of the bulk concentrates has never been exceptionally high on sulphide ore, ranging from 13% Cu (46·5% Pb) in 1949 to only 11% Cu (54% Pb) in 1954.

Effect of Calcium Zinc Cyanide on Copper-Lead Separations

For many years a large concentrator in the Western United States, treating a complex copper-lead-zinc ore, containing gold values as well, has made a copper-lead separation on a bulk copper-lead concentrate produced by conventional selective lead-zinc flotation procedures. Originally sodium cyanide in amounts as high as 15 lb. per ton of bulk concentrate was used to effect this separation, the copper, mainly as chalcopyrite, being depressed by the cyanide. Inasmuch as both copper and gold are soluble in strong cyanide solutions losses of these metals from the solutions going to waste each day from thickening and filtering of the copper concentrate always accompanied the use of sodium cyanide.

Mill testing with both ammonium zinc cyanide and calcium zinc cyanide demonstrated their ability to depress the chalcopyrite as effectively as did the sodium cyanide but with very substantial reduction in both soluble gold losses and soluble copper losses. The use of calcium zinc cyanide as a modifying agent at this concentrator for the separation of galena from chalcopyrite by flotation is now standard practice, about 0·40 lb. per ton of ore being used. This reagent can be readily prepared by reacting a slurry of pure zinc oxide with *Aero* brand cyanide, or reacting a solution of zinc sulphate, which has been neutralized with lime, with *Aero* brand cyanide.

Effect of Ferrocyanide on Copper-Molybdenum Separations

The " Morenci process " for the separation of molybdenite from molybdenum-bearing copper concentrates is described in U.S. Patent No. 2,664,199 to L. M. Barker and O. E. Young, assigned to the Phelps Dodge Corporation, and involves the novel use of sodium ferrocyanide as a modifying agent. Molybdenite is easy to float, but separating it in the final stages of cleaning from small amounts of copper can be very difficult. After several cleaning steps a large weight of molybdenite is being floated from a small

weight of copper, involving difficulties in mechanical entrapment and handling. For example, feed to the final recleaner step might run 73% molybdenite and 6% copper, while the final molybdenum concentrate might run only 0·4% copper and 85% molybdenite.

Essentially, the process consists of three steps :—

(1) Copper depression with sodium ferrocyanide and sufficient sulphuric acid to adjust the pH between 6·5 and 7·5, in a series of molybdenum flotation steps to give a product relatively high in molybdenum (50% to 70% molybdenite).

(2) Regrinding this concentrate to liberate molybdenite locked with either copper or insoluble gangue materials.

(3) Copper depression with sodium cyanide in the final series of molybdenite flotation steps at a natural pH, resulting in the final molybdenite concentrate.

Effect of Palcotan and Palconate as Modifying Agents

Of real interest to the flotation industry during the past several years are two reactive chemical products derived from redwood bark. This raw material contains a high percentage of phenolic acids readily extractable by mild processing methods. Palcotan is the sodium salt of sulphonated organic acids while Palconate is the sodium salt of these acids.

The chemicals are unlike paper-mill waste products, since the mild conditions under which they are extracted preserve the natural chemical reactivity. These products have many characteristics analogous to tannins. Palcotan and Palconate are manufactured by the Pacific Lumber Company 100, Bush Street, San Francisco 4, California. These products are finding wide use, replacing quebracho for the depression of calcite and quartz in the flotation of scheelite and fluorspar. They should also be investigated in the flotation of sulphides wherever contamination by calcite, dolomite, and certain types of siliceous minerals is a problem.

Effect of Aero Modifier 160

A new modifying agent used for the selective depression of gangue slimes is described in U.S. Patent No. 2,740,552 titled " Flotation of Ores Using Addition Polymers as Depressants," by F. M. Aimone and R. B. Booth, assignors to American Cyanamid Company. This type of modifying agent has been found to be useful wherever gangue slimes are a problem either by reporting in the flotation concentrate or by interfering with the flotation of the valuable minerals. When used in amounts ranging from about 0·01 lb. to 0·10 lb. per ton of feed improvement in grade of concentrate or recovery, or both, has been obtained on various types of ores (including lead, copper, and zinc sulphide), and non-sulphide ores (including scheelite, barite, fluorspar, etc.).

The 600 Series Aero Depressants as Modifying Agents

The 600 Series *Aero* depressants were originally developed at the Cyanamid Research Laboratories for the depression of carbonaceous gangue in the flotation of gold ores. Such carbonaceous material will often report in auriferous concentrates to such a degree that cyanidation of these concentrates is impossible due to the precipitating action of the carbonaceous gangue diluent.

Their widespread use in milling operations has demonstrated conclusively that a large portion of the carbonaceous and certain other flotable gangue constituents of ores may be depressed by the 600 Series depressants. In some cases metallurgy has been so improved that the ratio of concentration has more than doubled due to the elimination of gangue. This, in turn, has resulted in a marked reduction in the moisture content of the concentrates and has markedly improved thickening and filtration operations. Simultaneously, with an improvement in ratio of concentration, many plants have effected increased recoveries with reduced reagent consumption as a result of better control of the gangue minerals. Another application of these reagents has been to depress pyrite and slimy gangue in copper ores where the copper mineral is sensitive to cyanide.

Conclusions

Steady progress has been made during the past 30 or more years in increasing the selectivity of separations in flotation practice. This has been brought about, in general, by the judicious application of old and new modifying agents.

Although the proper selection of a promoter in a given flotation circuit is quite critical, it is also very important to make sure that modifying agents and frothers are chosen that will give maximum ease and control of

operation, recovery of values, and selectivity of the mineral to be floated when used with any given promoter.

The milling industry to-day has at its disposal a vast array of modifying agents, as well as promoters and frothers, to help in the solution of almost any problem. Although there are no tailor-made promoters for the flotation of specific minerals and no rules—that is, no definite rules—to be guided by, the mill superintendents and flotation engineers the world over are doing a grand job with the tools at their disposal, guided carefully by their own experience and artistry.

Congress in Canada

Notes on the Dominion tours of delegates to the Sixth Commonwealth Mining and Metallurgical Congress

John A'C. Bergne, A.R.S.M., M.I.M.M.

Vancouver

Assembling in Vancouver for the Sixth Commonwealth Congress delegates naturally found the first two or three days rather hesitant, but with a background of sight-seeing and entertainments of a quality which can be found in this City and its spectacular surroundings there was never any lack of local subjects to discuss and so bridge that awful gap in common interests to be found when strangers meet. The University and its beautiful endowment lands, looking out on to the Straits of Georgia, Stanley Park with its square miles of natural forests and gardens flanking Burrard inlet, and the heights of North Vancouver all contribute to produce a unique setting for this fast growing metropolis of 250,000 people.

An interesting visit was arranged to Boyles Bros. diamond-drill manufacturing works and head office, a visit considered very well worthwhile. The firm's large and well equipped workshops turn out the whole range of equipment offered, including diamond-drill bits. A demonstration of the construction of the latter from carbon moulds, their setting with diamond using suction pencils and glue, and the subsequent filling and sintering of the cobalt alloy from mixed powders was an absorbing spectacle. A new feature is a lightweight drill named the Bazouka. This is essentially a stoper fitted with a powerful rotary vane motor and using an airleg which can be anchored in a variety of positions for different types of drilling. Designed primarily for blasthole work and for ore-body delineation from drives, its principal advantage lies in its lightness, making it easily transportable and operable by one man only. With a vane motor of either 11 or 16 h.p. and a $5\frac{1}{2}$-in. air-feed cyclinder, the Bazouka's capacity is 100 ft. to 150 ft. with E type equipment.

Another interesting tour was to the Pacific National Exhibition. This is a permanent exhibit of British Columbia products, but it also houses museums and collections of various kinds, while the Exhibition Park houses the Empire Stadium, garden, and forum, all of which cater for organized sport. Of unusual objects which drew the attention of many delegates an outstanding one is a relief map of the whole of British Columbia on a horizontal scale of 1 in. to the mile. As the area covered is approximately 500 miles by 1,000 miles this exhibit requires a special chamber with galleries from which to view it, while a travelling gantry is provided from which the lecturer, in our case Dr. Kidd, can point out the subjects of his discourse.

Other tours included visits to the Grosvenor Laing Company's industrial development area on Anacis Island, to the mountains on the north shore of Burrard inlet, up which two ski lifts operate, and an evening trip by the 5,000-ton S.S. Princess Patricia, which took the entire Congress of nearly 500 people well up into Howe Sound during a memorable evening's dining and dancing.

Northern Aerial Tour

Having spent three days making friends, the group which had been so rash as to put their names down for the Northern Aerial Tour were reft from the rest of the Congress at what was then considered an early hour

Delegate Party Entertained in Vancouver.

but in retrospect seemed a gentlemanly time to travel and were flown soon after dawn from Vancouver north to Terrace on the Skeena River, where a wartime landing strip gives quick access to the Kitimat smelter of the Aluminum Company of Canada.

As the morning was clear and fine delegates were able to take the direct route along the Coast Range, passing alongside Mount Waddington (13,000 ft.), Monarch Mountain (11,700 ft.), and over Howe Sound and numerous glaciers, lakes, and inlets. The flight also passed over the Kemano Power Station, but a certain amount of low cloud masked the power house site. The group was lucky, however, to strike Kitimat in brilliant sunshine and very fine views were obtained of the extensive housing estates with their gardens which have been so rapidly constructed by the Aluminum Company of Canada. The smelter proper was as usual, so we were told, partly obscured by smelter smoke. The flight passed on to the Terrace air strip, whence members were taken by bus some miles into the town where various lodgings for that night had been arranged.

Kitimat

On the run down from the air strip the name of Terrace could be appreciated for here and in other places further north members were astounded at the enormously thick flat-topped benches of coarse gravel left behind on the valley sides, supposedly as the rivers re-sorted the moraines of dying glaciers.

The whole atmosphere was very informal. Having dumped their bags in a pile at the hotel foyer and having inspected the bar (Men) but not the bar (Women) because no-one could be found to escort to the latter the train was boarded about noon, all delegates feeling very hungry. When the train eventually started the first of the gargantuan buffet feasts was provided which were to be met frequently, right across the continent. A whole coach had been stripped of furniture and the substituted trestle tables down its entire length groaned under the food every time the train lurched. Needless to say, full justice was done to the very kindly and most judiciously delicious efforts of the community.

It is about 40 miles from Terrace to Kitimat, but the train follows a tortuous route over a pass and takes 1½ hours on the journey. On arrival buses awaited the party and thereafter three or four hours were spent embussing and debussing as various points of interest scattered over the very large area were inspected. When all felt really exhausted they were wonderfully revived at the " Rod and Gun Club," and proceeded therefrom to a fine sit-down

dinner and to listen to the speeches of welcome.

Kitimat is too vast to take in easily on a sightseeing trip of a few hours duration. For instance, the silt on which it was proposed to build the smelter was found to be unstable and this has had to be removed to a considerable depth and replaced by a consolidated gravel bed on which the 10-ft. mat of concrete needed to bear the weight of the pot lines could be laid. Circumstances favoured the venture, however, for ready to hand, within a mile or two of the plant, was another of these gravel benches which have been referred to previously. This one, well over 100 ft. high, has supplied excellent aggregate and sand for the many hundreds of thousands of tons of fill and concrete already used.

A visit was paid to the pot lines. Here all cameras and watches were left behind, the latter because of the strong magnetic fields encountered where the high amperage current is used. The output of 180,000 tons per annum at 500 tons a day comes from 702 pots at 1,500 lb. per pot in what appear to be two triple and three double lines. This rating allows for 35 pots to be under repair at any time. The great aisles were impressive, for each pot occupies some 20 ft. of floor space, giving a double line of 60 a length of upwards of 1,200 ft.

The alumina, unloaded from the holds of ships, by means of grabs of three suction heads acting on the same principle as in grain handling plant, is maintained in bulk storage and fed by conveyor-belt to piles on the floor beside each pot, whence it feeds automatically through side openings by melting into the cryolite cover of the bath. Occasionally the alumina becomes encrusted and it is then broken up by a pneumatic crust breaker at the end of a manoeuverable arm mounted on a self-propelled truck.

The molten bath, estimated at about 27 sq. ft. in area, is maintained as nearly as possible at 960° C. and about 1,500 lb. of metal is tapped once in 24 hours up into a 6 ft. diameter covered holding kettle by applying suction to a dipping nozzle thrust through the alumina ports. The bath holds 12 in. to 16 in. of aluminium under a cover of about 4 in. of cryolite. The important adjustments in level, particularly of anodes in relation to the top of the accumulating melt, are effected by electrically-operated jacks, the busbar and studs sliding in the soft upper portion of the self-baking Soderberg paste anodes. Escaping fumes are collected in a ring duct on the under side of the pot casing. The holding kettle transfers the molten aluminium (99·5% Al) to holding hearths maintained at 750° C ; these are of both oil-fired and electrical induction type. Thence the metal is fed to the casting machines, which are of two types, three revolving multiple moulds produce the standard 22-lb. billets, while a new type of continuous casting machine is also used in which a base plate retreating vertically allows a continuous flow of molten metal to solidify slowly in a water-cooled form while maintaining its upper surface at a constant level. This last machine produces the new 1,500-lb. Tee bar, which has been designed especially for handling by fork-lift trucks.

The fifth generating unit was completed at Kemano early this year ; each develops 150,000 h.p., giving a total of 750,000 installed h.p. The power is transmitted over the 45-mile route at 280,000 V.

A visit was paid to the rectifier house, where each pot line is supplied by eight ignition-type mercury-arc rectifier equipments each rated at 12,500 kW. These convert to 500 to 1,000 V. d.c. according to the number of pots on line at about 96% efficiency. The main problem with the rectifiers is one of cooling. Water is the medium used at present. It is maintained at 35 lb. per sq. in. pressure.

The figure for capital cost was given at $500,000 per pot or a total of approximately $350,000,000. This figure is assumed to include the whole of the Kemano power project in addition to the smelter at Kitimat. It is interesting to calculate approximately how large is the amortization of these same figures as the cost per lb. of metal.

The greater part of the company's debenture and loan stock has been issued since 1950 and is presumably largely for the Pacific project, including Jamaica. This amounts to approximately $210,000,000, averaging a little under 4% interest and matures in the early 1970's. The remaining $140,000,000 will have been found from earnings. The annual interest and amortization charges for these amounts can now be set out as under :—

Interest at 3⅞% on $210,000,000	2·25 ct. per lb.
Sinking fund at 4% compounded over 15 yr. on $210,000,000 .	2·92 „ „ „
Sinking fund at 4% compounded over 30 yr. on $140,000,000 .	0·70 „ „ „
	5·87 ct. per lb.

Perhaps higher sinking fund rates can now be negotiated giving a charge a little nearer 5 cents per lb.

The labour force of approximately 5,000 is divided into about 1,000 men on independent outside jobs, mainly construction, while the remainder makes up the smelter complement of permanent day men and four alternating shifts. These last work 21 shifts in a four-weekly period and in this way have a whole 24-hour break after their spell of 8-hours night shift every fourth day. The lowest wage rate is \$1·69 per hour basic and an average is about \$1·85 basic. Disregarding the men on construction and allowing for 5% staff at 50% higher average pay there is a 5 cent per lb. labour cost. As the cost of room and board in a company bunk house is only \$60 per month savings can be considerable over a period, notwithstanding current personal expenditure on cars, radio, and the like. Although there was a strike in progress at the company's eastern plants, no sign of labour dissatisfaction was evident at Kitimat.

The township at Kitimat is laid out on a grand scale on two main elevations and about 2,000 permanent dwellings have been constructed, including over 100 apartment units (flats). These include a church, hospital, and school. Although the company houses its bachelor employees, most of the married people build their own quarters. These cost \$14,000 to \$15,000 per unit of 1,400 sq. ft. in single or double units. This price includes oil-fired heating equipment, but without many of the other fittings considered essential in Canada. Of frame and plywood construction with aluminium insulation, these units are usually of a semi-basement bungalow type, bulldozers piling up against the foundations the material dug out thus create a revetment to provide for good run off of water in the thaw. The bungalow type calls for only a 5% down payment, about \$750.

Climatic conditions at Kitimat are relatively mild but damp, the monthly average temperature range being 60° F. to 23° F., although extremes of *minus* 2° F. and 85° F. have been recorded. Rain and snow give a combined precipitation of 90 in.

Other Properties

In addition to the places visited by the Congress mention must be made to two new undertakings of importance :—

Cassiar Asbestos Corporation, Ltd., in which Conwest, Newmont, Raybestos Manhattan, and Turner and Newall are interested, is operating a high-grade asbestos property in the far north of British Columbia near the Yukon border, some 90 miles west of the Alaska Highway to which it is connected by road—its only means of access. Capitalized at \$3,800,000, it is believed to have developed over 9,000,000 tons of ore with no limits reached at an average grade of \$30 per ton of 3 k and 4 k fibre.

The other undertaking is the exclusive prospecting and water power right given by the Provincial Government of British Columbia to the Swedish Wenner Gren interests subject to certain prior rights.[1] This covers an area of about 40,000 square miles centred on Finlay Forks, where the eastward flowing Peace River is born of the southward flowing Finlay and the northward flowing Parsnip. The latter rivers occupy the Rocky Mountain Trench and the gorge where the Peace River breaks through the mountains to the east could be the site of one of the largest hydro-electric plants in the world. A power project is being investigated by Wenner-Gren B.C. Development Co. in conjunction with British consultants. The area is also being prospected, partly to ensure that no mineral or oil deposits will be submerged by the proposed lake and partly on likely terrain.

Recent Legislation

While on the subject of British Columbia mines one cannot omit mention of mining legislation enacted during 1957.[2]

Four Bills have received assent. They are :

No. 17/57—Mining Tax Act.
No. 23/57—Metalliferous Mines Regulation Act.
No. 87/57—Mineral Property Taxation Act.
No. 91/57—Mineral Act Amendment Act, 1957.

The first re-defines the words "processing," "mine," "minerals," "mining operations," it also allows apportionment of the \$25,000 exemption for a whole year to a part fiscal year and fixes 8% as the appropriate annual depreciation of plant and machinery but not less than 15% or more than 65% of the net profit after certain deductions.

The second is concerned with the competence of the miners and regulates the issue of Certificates of Competency from managers to miners.

[1] See THE MINING MAGAZINE, April, 1957, p. 225.
[2] See THE MINING MAGAZINE, May, 1957, p. 286.

In the third owners or grantees of mineral claims or rights are rendered taxable on the value of minerals within or under an assessed parcel of land.

The fourth concerns the holding of mineral claims and the work necessary to be done, or cash paid in lieu, to hold such claims. Also there are provisions for forfeiture in case of non compliance.

These enactments have aroused considerable comment, but on the face of it No. 17 and 91 appear to bring British Columbia into line with common practice elsewhere. No. 87, however, may prove difficult to apply, for mineral valuation is not by any means an exact science.

(*To be continued.*)

New Coal-Production Technique

Raymond F. Mueller [1]

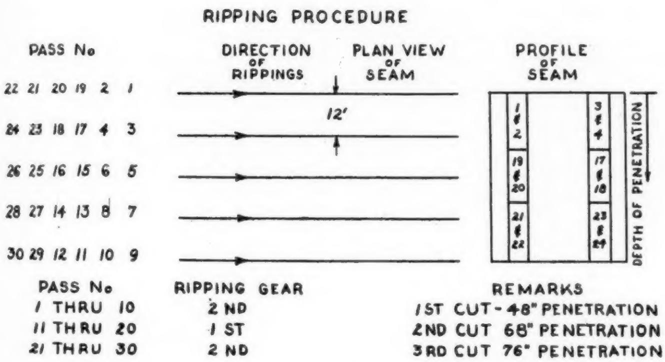
The use of a tractor-mounted ripper to break seams is described

What is considered to be a new concept in open-pit mining—breaking coal seams with a tractor-mounted ripper—is proving an effective and economical answer to rising production costs. Pits in Illinois, Pennsylvania, Kentucky, and Missouri where the new technique has been given a thorough testing have realized definite benefits over ordinary methods of breaking the seam. Indeed, during daily pit operations rippers mounted on crawler tractors have shown more versatility, more production per hour, and less cost than either drilling and blasting or pinning methods.

[1] Mining Representative, Caterpillar Tractor Co.

Ripping as a production technique was

Tractor Pulling 8-ft. Ripper.



Ripping Pattern.

made possible by the recent development of large hydraulically-controlled rippers mounted on the rear of tractors in the over-300 h.p. class which have been developed over the last few years. The combination of the two machines into a unit allows the ripper to utilize the tractor's weight and power, for unlike former towed rippers which simply trailed the prime mover and exerted no down-pressure the tooth on the mounted ripper concentrates the entire weight of the tractor to give maximum penetration. With weights of tractors approaching 32 tons only the tractive effort of the prime mover and the size of the tooth limit the depth of penetration and the ability of the modern crawler to develop up to around 24 tons of pull at the drawbar makes ripping possible in seams of up to 6 ft. thick.

Complete fracturing of such a seam can be obtained with the new technique. During the passage of the tooth through the seam the coal is not only fractured at the point of the tooth's passage but lateral fractures caused by the lifting action of the tooth spread to the area between furrows causing the entire section of coal between furrows to be shattered.

To obtain proper results ripping procedure depends on the establishment of a pattern to fit the needs of the particular mine; each case must, in fact, be based on initial trials.

Using the procedure pictured in Fig. 2 a Kentucky mine saves £9,000 a year by ripping a 6·3-ft. seam instead of blasting, the block shown measuring 90 ft. wide and 200 ft. long. It actually took 69·64 min. for one tractor to break the coal, resulting in a production of 3,610 tons per hour. After the tractor completes the ripping assignment it joins two other 300-h.p. tractors to help them strip overburden. The three machines remove 60% of the overburden moved at the mine.

This added versatility for the seam-breaking machine pays off in reduced costs for the mine operator for one man and one machine can handle a variety of jobs and it is not necessary to have expensive equipment standing idle during other operations.

Other benefits also enter the picture. The use of rippers in place of blasting reduces potential danger from stored explosives with a possible lowering of insurance rates. In pits where no blasting is done the ripper, built to withstand heavy shocks encountered during operation, can lower expensive maintenance on shovels used in loading off the solid. Such shock reduction can result in longer life for high-cost shovel components. In addition, by having the seam broken the overall loading efficiency will be increased. One factor is reduction of voids; another is less loading time per haul unit, giving increased haulage efficiency.

Even though the tractor-mounted ripper does save money over other methods by its versatility the biggest resulting economy is in actual production work. In pits where the technique was tested results showed amazing cost and work reduction per ton.

In a Fulton (Illinois) county a tractor-mounted ripper with an 8-ft. tooth broke a 4½-ft. seam of No. 5 Illinois coal, the average production being 2,332 tons of raw coal per hour. Approximate costs of the ripper operation were £45 per 8-hr. day, including labour. Opposed to this was a blasting cost of £115 per day. Blasting costs included caps, powder, drill, and labour while the tractor-ripper costs were based on depreciation, fuel, lubrication, estimated repairs, and labour. In this case use of the ripper resulted in a daily

saving of £69 and a yearly (203 days) saving of £14,000. In this pit the tractor ripped a block of coal 330 ft. long, 45 ft. wide, and 4·5 ft. deep in 47 min. including all delays. The block contained 2,845 tons. Ripping on 4-ft. centres in two passes the tooth reaching down 37 in. on the first pass. On the second pass the tooth reached 55 in. to the fire clay below. The average speed on the first pass was 2·2 miles an hour and 1·88 miles an hour on the second. After completing its passes the tractor doubled in bulldozing and general work around the area.

Again, at a Pennsylvania bituminous mine a tractor mounting a ripper with a 28-in. penetration worked five seams varying from 16 in. to 4½ ft. in depth. Blasting costs at the mine had been running at 3d. a ton for powder alone with labour costs for the two-man crew additional. Rock spoil was removed with regular loading shovels, requiring extra work for the big machines. With its ripper the tractor broke the seam, making it easier for the shovels to handle. With its bulldozer blade the tractor moved rock spoil away from the area, freeing the shovels for loading. To uncover the seams and rip them as well as handle other operations as needed the tractor-ripper combination has reduced cost at the mine by as much as 50% according to the owners. They also find that ripping has done away with the deadening of the coal caused by blasting.

A tractor-ripper in a Missouri pit again showed definite gain for the owner. On a 30-in. seam 65 ft. to 80 ft. wide the tractor was tried as a substitute for a pinning machine. With the tooth penetrating approximately 27 in. the block was ripped on 40-in. centres with the tractor in second gear. In this particular pit the hard coal is at the top of the seam and the tooth does not have to penetrate all the way to the bottom of the seam to achieve proper breakage. With the pinning machine the mine owners calculated that they were saving 3½d. per ton over blasting but the process was slow. The tractor-mounted ripper was able to break enough coal in 1½ hr. to equal the production of a full 8 hr. with the pinning machine. Although statistics were not available the owners say that the ripper represents an additional economy over the pinning machine. Bulldozing and general work are also handled by the tractor when it is not engaged in seam ripping.

Another mine owner has stated that the use of the tractor-ripper " practically eliminated all delays at the tipple," while making an increase in production possible.

Although it is able to shatter the coal completely the tractor-mounted ripper does not produce an excess of fines but tends to equal or lessen fines as compared to blasting in most cases. With a need for more efficient operations to counter constantly-rising costs of production the new concept should have a wide appeal.

Mineral Dressing Processes in Review—II.

A review of proceedings at the recent Stockholm Congress is concluded.

E. J. Pryor,[1] A.R.S.M., D.I.C., M.I.M.M.

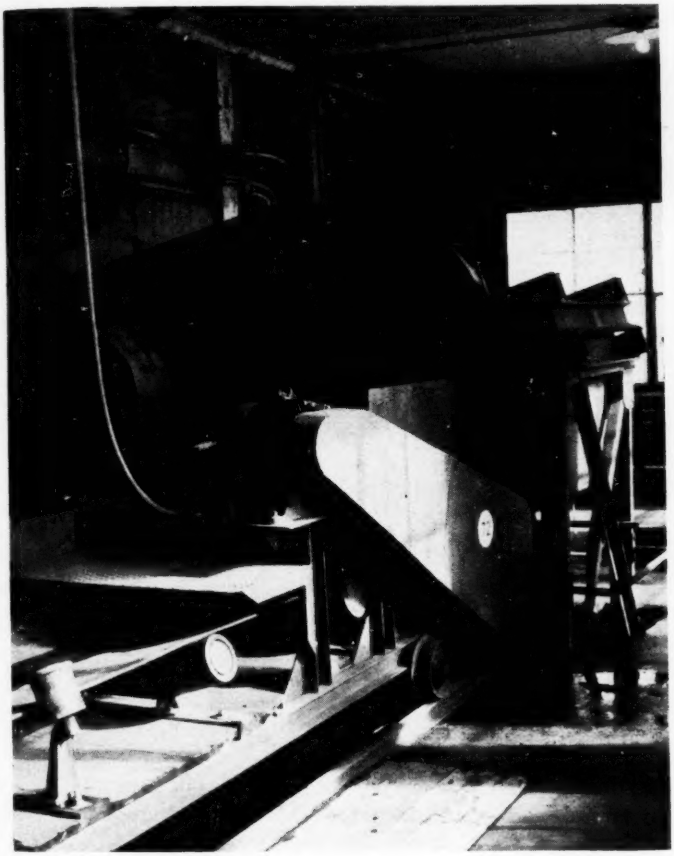
In an earlier article the first four sessions were briefly summarized. A similar condensation is now made of the papers presented in the four final meetings.

Session V.—**Flotation of Sulphide Ores**

The first paper (V.1), by F. W. McQuiston (U.S.A.), dealt with the flotation of copper-lead-zinc complexes ; it is concerned with practical experience at a number of plants.

[1] Reader in Mineral Dressing, University of London (Royal School of Mines).

Selective flotation which at one time was common practice for copper-lead-zinc minerals is now less used than the selective reflotation of a bulk concentrate of the copper-lead. Zinc and iron sulphides are depressed and the copper-lead is then reclaimed from them. The main processes used are called the cyanide, the sulphur dioxide, and the dichromate methods, which can be mixed. Buchan's practice, with sulphur dioxide, was developed in 1936 and remains in constant use. A bulk copper-lead



Top of Belt Shaft, Grangesberg Mill.

concentrate is treated with SO_2 at some 35% of solids and is then conditioned with sodium bichromate prior to depression of the lead at a pH of 5. Instead of straight cyanide salts a zinc cyanide complex is favoured where dissolution of gold and copper must be avoided. Chalcopyrite is depressed with a mixture of zinc oxide and cyanide or of zinc sulphate and cyanide provided the sulphate is neutralized sufficiently to give the cyanide protective alkalinity. A Cyanamid reagent (Reagent 675) is available for similar work. Variation in practice from mine to mine seems to be influenced by the need to float the lower mineral in the ratio of the two and to sink the more abundant one.

Paper V.2 by Professor M. Rey (France) attempts a classification of the lead-zinc ores and of the techniques used in their treatment. The principal influencing factors are considered to be the abundance and nature of the iron sulphides, the degree of oxidation, the basic or acidic nature of the gangue, and the amount of copper mineral present, if any. A basic gangue is taken as one containing enough limestone to neutralize acid and precipitate any ferrous sulphate derived from oxidation. Calcium sulphate is generated during such chemical reaction and is of importance. The equation :—

$$2\ FeSO_4 + 2CaCO_3 + 3\ H_2O + \tfrac{1}{2}O_2 = 2Fe(OH)_3 + 2CaSO_4 + 2CO_2$$

applies also to the precipitation of zinc and lead as their hydroxides. The gangue, therefore, controls to a great extent the soluble salts. It also controls surface contamination of the sulphides. Rey's classification is

into : (*a*) Unoxidized ores ; (*b*) oxidized ores with an acid gangue ; (*c*) oxidized ores with a basic gangue, and (*d*) ores containing copper minerals of secondary origin. Examples and details of reagent combinations and results are then given.

Paper V.3 on the separation of bulk sulphide concentrates by flotation is by A. S. Konev and L. B. Debrivnaja (U.S.S.R.). These authors investigated the desorption by sodium sulphide of collectors from a mineral surface, using the captive bubble to reveal changes. From this a new flow-sheet was worked out for a Russian plant. As a result selective flotation hitherto practiced has been replaced by bulk concentration. This is followed by conditioning with sodium sulphide, dewatering, and washing to remove reagent and soluble salts. The washed concentrate is then reground and separated by a conventional flotation process. Using this technique a coarser grind is possible with greater economy in the general plant practice. Advantages claimed for the change included higher throughputs owing to the fact that coarser grinding can be used followed by an intensively strong bulk float. This can be applied to many ores. Instead of having to deal with a selective process which is hampered by the presence in the pulp of primary slimes, metal hydroxides, and soluble salts the separation is made from the cleaned bulk concentrate which has been freed from harmful impurities. Important improvements in metallurgy have resulted together with lowered tailing losses. In addition to higher-grade concentrates there has been an overall lessening of the use of such flotation reagents as potassium cyanide, zinc sulphate, and copper sulphate.

Session VI.—**Flotation of Non-Sulphide Ores**

Professor P. G. Kihlstedt (Sweden) deals with the flotation of haematite using tall oil emulsions in Paper VI.1. A new type of collector consisting of an emulsification of tall oil and fuel oil in water has been used and has given good results in batch and pilot-plant testing. The paper is also concerned with the selective separation of hæmatite and apatite in this work. The ores which are of special economic interest in Scandinavia are silicious hæmatites and magnetites containing phosphorus amounts varying up to 0·3% and apatitic iron ores with more than 0·3% of phosphorus. The common requirement is correction of a phosphorus content, that element being usually present as calcium fluorapatite. In straight flotation with UMIX reagents the apatite and hæmatite float with equal readiness at about the normal pH of 6·5. For selective flotation the basic condition seems to be a pH control which differentiates between the calcium minerals and the iron ones. Calcium floats at about 8·5 but the iron does not. Iron floats at about a pH of 5·5 but the calcium phosphate does not. This difference is accentuated in the presence of fluoride ions. At a pH of 2·5 to 3·5 iron ceases to float. Sodium silicate aids selectivity.

Paper VI.2, by P. Kivalo and E. Lehmusvaara (Finland), deals with an investigation into the collecting properties of some of the components of tall oil. The effect on a high-grade magnetite of such collectors as palmitic, stearic, oleic, linoleic and linolenic, ricinoleic, abietic, and some sulphated fatty acids was observed. The results confirm work by Hukki and Vartiainen as to the increase of collecting power of the 18-carbon-atom fatty acids with increasing saturation. Most of these are found in Finnish tall oil. Contact angle measurements were used for much of the work and surface tension measurements were made with a DuNoüy tensiometer. Much work remains to be done on this important process.

The next paper (VI.3), on the selective flotation of non-sulphide minerals, was by Professor M. A. Ejgeles (U.S.S.R.). As a result of the work described it has been possible to separate fluorite from calcite, fluorite from barite, calcite from apatite, diaspore from pyrophyllite, etc. Selective depression has played an important part in this work and among the reagents used were dextrin and sodium silicate for the separation of fluorite from calcite, potassium bichromate and dextrin for fluorite from barite, and starch and lignin sulphonate for separating diaspore from pyrophyllite. All this was done in softened water. Radioactive isotopes were used to prove that there was no direct relationship between the floatability of minerals and the density of the collector layer on their surfaces in the case of fluorite. An important function of depressing agents apart from reducing the amount of collector which is absorbed is their direct effect on the wettability of the mineral surface.

The fourth paper (VI.4) was not discussed. It was by J. Levin (S. Africa) and dealt with the flotation of uranium from the gold-uranium ores of the Witwatersrand and Orange Free State. The mineral concerned is

Lead Cleaners, Zinkgruvor.

thucholite and some 20% to 30% of the uranium can be floated with a frother only. When xanthate is added recovery rises to between 30% and 70%. Some ores can be floated with oleic acid and altogether 80% of the uranium is recoverable in a 20% weight of concentrate. If cyanidation precedes uranium recovery the results are poorer, but this can be overcome by acid treatment and washing before flotation. After presenting a a great deal of valuable information, partly in tabular form, the author goes on to discuss the practical application of flotation. Each of the procedures described is applicable potentially to the concentration of uranium from the South African ores; it all depends on economic factors. With three exceptions in South Africa acid leaching of the cyanide residues without prior concentration has been preferred. Flotation to concentrate uranium is practised in three mines, in each case the uranium content of the ore being too low to permit direct leaching; in each case the carbonaceous sulphide concentrate is floated. The pyrite and other sulphides add to the concentrate produced and are recovered after acid leaching by reflotation. The uranium as U_3O_8 in the flotation feed varies from 0·005% to 0·0085% and the concentrate contains from 0·039% to 0·051% representing a recovery of between 36% and 49%. Reagents include sulphuric acid, reagent 301, or sodium isopropyl xanthate, Aerofloat 25 or mixed aerofloats 15, 31, and 33, frother 70, or cresylic acid, the latter with pine oil. The pH for flotation is between 5·0 and 5·7 and the cost of treatment in pence per ton of the flotation feed varies from 13d. to 27d. This does not include amortization and handling of material to the plant. Over 90% of the sulphides are recovered in this treatment and the author considers there is a good case for considering the treatment of several other low-grade uranium ores by flotation.

Session VII.—Mineral Processing by Chemical Methods

The first paper here (VII.1), by Erik Svenke (Sweden) was called " Some Aspects of the Uranium Milling Industry " and presents a useful review of current practice, together with some technical and economic forecasts. Present techniques are chemical and use either acid or alkaline solutions according to the gangue minerals. Pyrite consumes alkali and a limestone or dolomite gangue acid. Uranium occurs either in the tetravalent or hexavalent form, the latter being more soluble in both alkalies and acids. Oxidizing agents are, therefore, used in the chemical treatment of tetravalent uranium ores. In alkali leaching which usually gives a lower yield a finer grind is needed than with acid leaching and if any appreciable amount of sulphur compound is present there may be

high reagent consumption owing to sulphate formation. Pre-treatment by ore-dressing methods for removal of gangue can alter the requirements of an economic treatment. For acid work sulphuric acid together with manganese dioxide as the oxidizing agent is widely used. In the alkaline process an aqueous solution containing sodium carbonate and bicarbonate is used, the latter being required to compensate formation of hydroxyl ions. These would precipitate sodium uranate. The process depends on the ratio of carbonate to bicarbonate and on the absolute concentration of these ions. Oxidizing agents are usually needed. The pregnant solution carries excess carbonates and bicarbonates so regeneration must be used. Leached liquids from an alkaline process are comparatively clean but uranium-carrying solutions from acid processes are usually rather impure and their uranium contact may be 0·1 grm. per litre together with some hundreds of times this concentration of impurities. Ion-exchange methods are mainly used for recovery. The formula of the ion exchange process in which uranium is adsorbed as trisulphate is :—

$$UO_2(SO_4)_3^{4-} + 4\,RNO_3 \underset{\substack{\text{desorption}\\ \text{(elution)}}}{\overset{\text{adsorption}}{\rightleftharpoons}} R_4UO_2(SO_4)_3 + 4\,NO_3^-$$

where R indicates the resin.

Desorption is performed by means of acidified salt solutions such as nitrates.

The author gives illustrative flow-sheets. Direct application of conventional ore-dressing methods has thus far found only limited use but it is expected that flotation may in future play a more important part. The Patching summary of the aims of physical treatment [1] :—

(1) Preconcentration to reduce the bulk passing to chemical treatment ; (2) the removal of all constituents interfering with economy and efficiency of chemical treatment, and (3) recovery of other ore constituents of economic value, is briefly mentioned.

Based on some interesting economic calculations of the world's consumption of power the author considers that the present production capacity is about suitable to foreseeable requirements. The production level, therefore, depends to a high extent on the unstable military situation. Large-scale operators on to-day's costs can produce comfortably with the product selling at a price of $10 per lb. of U_3O_8. The U.S. Atomic Energy Commission has put forward its guarantee at the purchase price for the 1962 to 1966 programme at $8·00 per lb. This favours extraction from any ore-body with slightly less than 0·1% of uranium without dependance on any other values in the feed.

In a paper (VII.2) titled " Applications of Solvent Extraction in Processing Uranium Ores " J. Bruce Clemmer (U.S.A.) gives a condensed review of progress in this relatively new method of recovery. He reviews the laboratory and pilot-plant research work done at Salt Lake City for the Atomic Energy Commission. Broadly, solvent extraction is a procedure for separating components of a liquid solution by creating a two-phase system by the use of an auxiliary immiscible liquid with a specific affinity for one or more of the constituents. This in uranium metallurgy involves contact between an aqueous leach liquor or pulp and organic extracting liquid such as kerosene. After this extraction the now loaded organic liquid is put into contact with a suitable aqueous solution which removed its uranium and the phases are again then separated. This is called the stripping step. The process in some ways parallels resin ion exchange and Clemmer calls it liquid ion exchange in his paper. It is more rapid than resin ion exchange in which a cubic foot of resin can be loaded with between 3 lb. and 5 lb. of U_3O_8, but ordinarily produces 2 lb. to 3 lb. daily, while a cubic foot of 0·1 molar organic can be loaded with ¼ lb. to ½ lb. of U_3O_8 and normally produces from 4 lb. to 8 lb. of oxide daily. A cubic foot of resin costs about $45·00 and a cubic foot of 0·1 molar organic about $4·00. Clemmer ends what he calls his thumbnail sketch of the highlights of recent work with organic solvents by noting the inherent flexibility and potentially numerous applications of solvent extraction in the processing of uranium and other ores.

Paper VII.3, " The Influence of Fluidized Roasting on Hydrometallurgical Processes," by J. D. Grothe and B. H. McLeod (U.S.A.), gives details of recent advances in the use of the Dorrco Fluo-Solids roasting system as used in the treatment of ores and concentrates, notably as preparation for hydrometallurgical separation. Among the instances cited are the production of electrolytic-grade copper direct from chalcopyrite con-

[1] Patching, S. W. F. " Solvent Extraction and the R.I.P. method." Instn. Min. Metall. Symposium, Mar., 1956.

centrates ; the separation of copper from zinc both at high purity from complex associated sulphides which did not respond to physical means of separation ; solution of cobalt from a chalcocite-carrolite concentrate, and solution of cobalt contained in pyrite without chloridization. The Bagdad Copper Corporation pilot work is cited, in which part of the object was to produce a supply of leach acid for treatment *in situ* of part of the ore-body. This has been done without allowing too much iron to enter the solution. The 5-ton-a-day pilot plant is being succeeded by a full-scale one in which operation is expected to be simpler owing to the difficulty of scaling down in pilot work. In another plant concentrates carrying 50% copper as chalcocite and 2% of cobalt as carrolite have been successfully treated. Here the purpose is to sulphate the copper and cobalt while retaining as much of the sulphur as possible so that its regenerated acid can be utilized for leaching a high-grade cobalt oxide ore. Another case cited is the fluidized roasting of concentrates at the Dowa Mining Company in Japan. Here copper minerals are chalcopyrite and covellite with small amounts of bornite and chalcocite all intimately associated with finely-divided pyrites. Zinc is present tied with galena and chalcopyrite at too fine a grade for separation so a bulk concentrate is prepared. Fluid roasting followed by electrolytic treatment has proved successful.

The next paper in this session (VII.4), called " Investigations on the Chlorination of Non-ferrous Metal Ores," is by Hans Hohn, Gerhard Jangg, Loreliese Putz, and Ernst Schmiedl (Austria) and considers the possibilities of improving upon conventional metallurgical methods of treating poor and complex ores which call for high working temperatures and low purity of products. The authors deal with the probable advantages of chemical ore processing and particularly of the use of chloride metallurgy. They present thermodynamic considerations and discuss the technical and economic aspects of such treatments. These they consider include low working temperatures, high yield, and good separation of various metallic ore components. Examples are given of the processing of complex sulphides, mixed oxides, and sulphides and complex oxides. Some metal oxides may be converted to chloride by the use of chlorine alone, while those of other metals need the additional help of carbon as an oxygen acceptor.

The example of tin chloride is given, produced by the chlorination of cassiterite in the presence of powdered carbon at 700° C. at which temperature the silicious gangue is not affected. The tin thus produced is separated as its tetrachloride. Chemical processes tend to break through the barriers presented by oxide metallurgical methods used with classical smelting techniques. These chemical processes combined with hydrometallurgy, electrochemistry, and amalgamation have made possible the production of metals with improved properties.

The last paper (VII.5), the " Reductive Leaching of Ores, Especially Manganese Ores," by Professor G. Bjorling (Sweden), was not discussed. It notes that manganese occurs in its ores as a higher oxide and cannot be leached without first using pyrometallurgical reduction. If, however, the ore is leached under reducing circumstances a solution of manganous salts can be obtained. Thus, manganiferous limonite can be leached with dilute sulphuric acid in the presence of pyrrhotite as a reducing agent. The manganous sulphate solution thus obtained can easily be used to produce electrolytic manganese while regenerating the acid for further leaching.

Session VIII.—**Miscellaneous**

The next paper (VIII.1), by E. Cohen (England) and entitled " Simple Microscopy for Plant Control in Mineral Dressing," describes the use of the low-power stereoscopic microscope in the study of fine-grained minerals. It also points out the important value of this tool in plant control in grinding, gravity, and flotation operations. Several techniques and applications of the microscope to mill control not hitherto put together in a paper are described.

The final paper in the Symposium (VIII.2) is " The Tape Method, a New Method for Spectrochemical Analyses of Powderable Minerals," by A. Danielsson (Sweden). The paper describes spectrochemical analysis in which a sample is fed on to an adhesive tape which is passed continuously through a spark gap. This gives advantages over previous methods of spectrographic analysis of powdered material and in ore dressing allows a rapid analysis. It is presented to people active in the general field of ore dressing and does not go into details of specific interest only to specialists in spectrochemistry.

These two final papers were also not discussed but they concluded the main work of the conference.

Ore-Dressing Notes

(1) *Production.*

New Plant for Mesabi

The first three lines of the planned four-circuit plant at Coleraine (M. A. Hanna Co.) are now treating 800 tons of haematitic iron ore hourly using spirals and heavy-media. Up to 12,000 gal. of water are needed per minute. Crude ore is hauled from the pit in 34-ton end-dump trucks to a 100-ton surge bin which delivers *via* a reversible apron feeder either to the crushing units below or to trucks dumping to waste. After reduction to *minus* 5 in. ore enters the mill. If already of merchantable grade it is diverted to loading bins, but if it is to be upgraded it is next screened and washed to *minus* $1\frac{1}{4}$ in., *plus* $\frac{3}{16}$ in. for heavy-media feed, the *minus* $\frac{3}{16}$ in. material being sent to spiral classifiers.

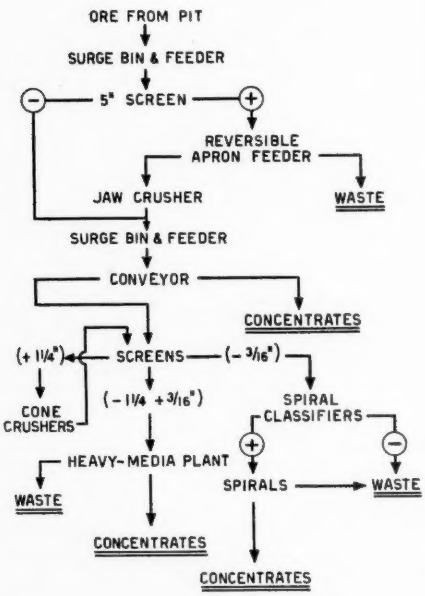


Fig. 1.

The classifier sands rank as concentrate while their overflow goes to the spirals plant. First, it is reclassified by two stages of hydro-cyclone treatment into two overflows which are discarded and an underflow which is roughed on a battery of 128 spirals, the tailing from which goes to waste while the middling recirculates. The rougher concentrates are cleaned in a battery of 64 spirals, their tails joining the rougher middling for recirculating. A condensed flow-sheet is shown in Fig. 1.

(2) *Treatment and Valuation.*

Uranium Concentrates

A description given in the *Journal* of the South African Institute of Mining and Metallurgy for March, 1957, covers the further treatment of the ammonium diuranate produced on the Rand. Dr. M. G. Atmore commences by describing the collection and weighing of slurry transported by tankers of stainless-steel or rubber-lined mild-steel construction. The slurry is thixotropic and, therefore, carries appreciable water, which aids in handling and sampling. On arrival at the plant the tanker is discharged to a rubber-lined sampling tank fitted with stirring mechanisms ; low-pressure compressed air may be used to assist this transfer. Agitation then proceeds for at least 30 min., after which dip samples are taken at designated depths or samples withdrawn by a special form of vacuum tube. The slurry is then transferred to a conical-bottomed holding tank and blended with slurries from other sources to ensure as level a grade of material for further treatment as possible. Before its return the transport vehicle is thoroughly washed and the dilute washings are saved for treatment. Thick slurry is fed to stainless-steel rotary filters for dewatering and a " floating cloth " principle is employed ; a thin and sticky cake could not be removed from a wired filter. Cake forming proceeds normally on the cloth but when low-pressure air is applied the entire panel, with its adherent cake, lifts from the face of the drum on to an inter-connected polished stainless-steel roller revolving somewhat faster than the drum which " leads " the cake from the cloth. This transferred cake is scraped from the roller by a rubber scraper and drops into an extruding device which causes pellets to be formed large enough to ensure that there will not be excessive dust at a later stage but small enough to let heat penetrate. The pellets retain their shape through all subsequent processes which includes drying on an endless-belt drier in steam-heated air and batch calcination in automatically-controlled muffled furnaces. The calcined material is sent by screw-conveyor to a bucket elevator

and transferred to packing and sampling units. Vezin samplers take a sample from the passing stream and the remainder of the material is packed in drums for shipment.

(3) *Air Cyclones.*

The Optimal Vortex Classifier

In an air-classification symposium reported in *Mining Engineering* for October, 1957, R. E. Payne describes an advance in classifier design which until recently was very empirical. Powder would be dumped into an air stream of non-uniform cross-section with no great effort to control initial velocity, secondary flow pattern, etc., and classifying efficiencies were low. Some ten years back a new idea appeared—the constant-cut-point classification zone. If a particle could be kept in this zone until its initial velocity had disappeared and if wherever it happened to be after that point it would be forced in one direction if below a certain size and in the opposite direction if larger than that size then an advance was possible. Even if the particle started the wrong way it would turn round and get into its correct track. For this it was necessary to suppress secondary flow patterns and the idea of a controlled vortex began to arise. In principle this could be adjusted to create the constant-cut-point classifying region for any feed material of given particle-size distribution. An immediate solution would be a high ratio of mass air flow to powder, but although this might work well in a laboratory model expansion to plant dimensions presents many difficulties not least of which is that of the cost of power. There is, however, one mathematically-established spiral vortex which can be maintained independent of particle-size distribution in both the feed material and the feed rate. It has been proved that this can be built for any size with identical classification performance and tests have now been made over capacity ranges from 200 lb. per hour to 20 tons per hour. Air introduced at the outside of the classifier is directed by vanes into a spiral flow. Then a particle in the classifying region has a radial outward centrifugal force acting in respect of its tangential velocity and radial inward drag force produced by the inward spiralling air. These can be balanced for a single particle size if proper air flow can be maintained throughout the classifying region and if particles can be brought up or down to air speed before they leave the classifying zone. If no forces act on the air stream in the tangential direction it has a free vortex flow, while if no tangential forces are exerted on the particle while in the classifying region it conserves its angular momentum. Consequently if a particle of a given size is introduced into the classifying zone at any point with the same angular momentum as the air the tangential velocities of the air and the powder remain perfectly matched at every point in the classifying region and there will be no interaction between powder and the air to alter the free vortex. This principle has now been incorporated in industrial design.

Another paper in the same symposium, by W. H. Lykken, makes several interesting points in connexion with the efficiency of air classification. He deals with grinding and classifying in the sub-sieve range and points out that when all the material must be reduced to less than, say, 10 microns a very considerable number of particles are handled for each pound of material. The formula for single microns is :—

$$\frac{25{,}400^3 \times 27\cdot 7}{\text{Sp. Gr.}}$$

$$= \frac{454{,}000{,}000{,}000{,}000 \text{ particles}}{\text{Sp. Gr.}}$$

Most material in this range could be considered as cubes with the corners knocked off making them more or less rounded. At this size they can be considered as a fluid highly and uniformly diluted by air and as there is adequate space between the particles each can move freely within the mass and there should be at least 1 lb., or 13 cu. ft., of air per lb. of solids. There must, therefore, be adequate dilution, complete and uniform distribution of the material in the air, and complete aeration ; although the discussion mentions rounded particles the shapes are quite individual for many materials such as plate-like clays, micas, etc., and shape affects the cut point. Efficiency is claimed with the optimum vortex classifier of 80% to 85% at *minus* 15 microns. If incorporated in an air-swept ball-mill there would be sharp reduction in circulating load. This under the circumstances would raise the grinding efficiency. The cut point is adjusted by varying the angle of the outside vanes, which is easily done, and the rotational speed of the walls of the classifier, which is effected by means of a change of the drive speed.

(4) *Flotation.*

Cinnabar Ores

Writing in the September issue of *World Mining* K. Kunze gives a valuable description of a novel approach to the flotation of cinnabar ores. He makes the point that the textbook method which includes the use of silicates as dispersing reagents is incorrect. The first cinnabar flotation plant to succeed was the 125-ton-per-day mill built in the Bottle Creek area, Nevada, and this was followed by the United Mercury Company's 125-ton plant, while still newer is the Bretz mine plant in Malheur County, Oregon, which mills 150 tons daily. Cinnabar floats readily enough but is depressed strongly by sodium silicate or soda ash, so that various other dispersion agents were tried in the test work preceding the construction of the three plants. These treat soft clay materials and dispersion is often necessary for good results. A lignin product made by a Pacific lumbering company proved to be the best of the numerous dispersion agents tried. Because cinnabar oxidizes rapidly in air flotation should start by activation with a heavy metal salt. Lead nitrate, lead acetate, and copper sulphate have been used successfully for this purpose. All three reagents affect frothing characteristics and the test work must, therefore, establish the one which is to be used. The reagent practice at the three mills referred to is on the lines set out in Table 1.

Table 1

Reagent.	*Used for.*	*Lb. per ton ore.*	*Added to.*
Palcotan . .	Dispersant	0·04 to 0·10	Ball-mill
Lead or copper salt	Activator .	0·20 to 0·50	Ball-mill and conditioner
Reagent 301 . .	Promotor .	0·20 to 0·50	Conditioner
Frother 65 . .	Frother .	As needed	Flotation cells

Flotation works best at densities of 20% to 30% solids in the pulp and pH between 6 and 8 although this is not critical. Recoveries of more than 90% are reported with a 30% to 50% mercury assay in the concentrate.

The advantages listed for flotation over direct furnace installation are greater flexibility on tonnage, better recoveries on low-grade, wet, or dust ore, less health hazards, and better re-sale market. Disadvantages include a more complicated flow-sheet and problems with grinding and water supplies. In general, the author considers mercury flotation plants to be best on soft very wet ores and for low-grade large tonnage operations. Direct furnacing is better suited to treating hard-type ores and for high-grade small tonnage operation. Flotation as a pre-concentrating process for existing furnace plants, however, appears promising.

(5) *Equipment.*

Crushing Control Panel

A control panel recently designed for a British crushing plant will handle the drives of 46 motors varying from $\frac{1}{2}$ h.p. to 50 h.p. These drive crushers, screens, elevators, conveyors, and complex feeders and since the main plant is partly enclosed visual control would be difficult. The operator, therefore, has before him on the panel a mimic flow diagram on which pilot lights signal the motors which are running, 80 different processes being cared for by the panel which has 17 " methods " and 20 " subsequences " worked by two multi-way selector switches. Half the panel carries the starting switches and half the relays, timer, selectors, and master stop-start push-controls. Only when all the ploughs and chutes have been correctly switched into their flow-lines by the solenoids worked from the panel can a start be made, a " ready " lamp showing when the setting is correct. When the starting button is pressed a hooter sounds for 5 sec. Then after a further delay of 10 sec. the motors start up at 15-sec. intervals, everything being shown as it occurs on the flow-diagram. Sequence interlocks ensure that the whole line shuts down in the event of a failure at any point. Limit switches operate when the bin which is the final destination of the processed material is full.

Book Reviews

Uranium in South Africa, 1946–1956 : A Symposium. Quarto, in two volumes. Vol. 1, 546 pages, illustrated : Vol. 2, 483 pages, illustrated. Price 126s. Johannesburg : South African Institute of Mining and Metallurgy.

These handsome volumes are in part a work of reference, in part a prestige publication, and in part almost of the character of a Blue Book. They cover all the aspects of the work done during the past decade and make it very clear that much valuable effort was directed to the programme. By reason of the fact that there are 30 separate papers in the publication there is necessarily a good deal of overlapping, but there can be very

little in the way of omission, except for the unfortunate fact that the grade of the ore is barely dealt with and for this it is quite certain that the authors will not be to blame. This omission from works which will undoubtedly be used for reference for a long time to come is the more unfortunate inasmuch as it has been possible for a long time now for those conversant with uranium resources to deduce these figures and also because in recent publications some of the figures have been made public.

The writer regrets his incompetence to criticize or evaluate most of the second volume of the work, but feels convinced that from the standing of the authors and the general quality of the first volume, the papers must deserve the attention of those interested in treatment and extraction ; and, as mentioned above, they are valuable reference material.

As regards the geology, the quality of the data cannot be overstressed. It is perhaps unfortunate that it has become an article of faith, largely dependent upon the country of residence, as to what theory of ore-genesis many geologists prefer. It is difficult for the reviewer to believe that there is not even a case for the hydrothermal school and impossible to avoid the belief that there is not a subjective content in this aspect of the articles. There can, however, be no doubt as to the high value of these papers concerning their factual material.

The section on history most fairly gives great credit to geologists outside South Africa, including George Bain and Charles Davidson. It is interesting to note that neither of these men, who pioneered the work from the mineral resources point of view, have remained in the world of Atomic Energy. That they are men of energy and imagination no one who knows them will doubt, and the reviewer asks to be permitted to ponder whether the stultifying effect of secrecy, carried beyond the bounds of necessity, may not occasionally drive such people away.

R. A. MACKAY.

British Borneo Geological Report, 1956. By F. W. ROE. Paper boards, quarto, 212 pages, illustrated. Kuching, Sarawak : Geological Survey Department.

Factual and well-presented statements on what is going on in Colonial geology are welcome and this volume is a most excellent example of its kind. It is simply and lucidly presented. It is well illustrated, containing both a large number of interesting photographs and numerous clear simple diagrams.

With these remarks as a background, a few minor criticisms may be permitted. There is a certain amount of space devoted to routine procedure of staff which is unlikely to interest the general reader and tends a little to make the layout jerky. It may be a point of pedantry on the part of the reviewer, but the words " economic geology " do not seem to him to be synonymous with metalliferous mineralization, particularly when the latter is in the same paragraph pronounced uneconomic.

The director and staff are to be congratulated on this work. No engineer or geologist wishing to do any work in Borneo could ask for a better start to their undertaking.

R. A. MACKAY.

Engineering Log

In a number of industries adhesive bonding is playing a major rôle, the process already permitting the combined use of metal, wood, rubber, plastic, glass, and other materials. Metal bonding is, however, more difficult ; other materials fail sooner than a really good glue, while metal does not. Although many adhesives give some degree of adhesion to metals such adhesion must be of comparable strength to that obtained by welding, soldering, brazing, or riveting if the strength of the metals is to be exploited. Adhesive joints have now been made which are effective against vacuum pressures as low as 10×10^{-7} mm. of mercury and fluid pressures of up to 2,000 lb./sq. in. Aluminium can, indeed, now be bonded to steel, brass, copper, plastic, wood, ceramic, glass, and rubber, various types of adhesive having been used successfully. The choice depends on the strength required, the accessibility of the parts to which it must be applied, and the possibility of heating or pressurizing the parts to be joined. Adhesives are made from synthetic resins set by a chemical action, which begins by the impulse of heat or by the addition of a hardener or catalyst. The three main groups of adhesives are as follows : (1) Cold-

setting, requiring no pressure; (2) hot-setting, requiring pressure, and, (3) hot-setting requiring no pressure. Group 2 adhesives are usually applied in two stages. A liquid is first brushed or sprayed on to the parts and then a powder applied to the coated surface. Heat causes the powder to flow and combine with the liquid and the pressure necessary to complete the combination will depend on the grain size of the powder—usually between 50 lb./sq. in. and 150 lb./sq. in. Adhesives do not normally require pressure but components frequently do—for instance, two thin metal plates must be pressed together so as to remain flat. Temperature and times depend on the adhesive used. Phenolic-based adhesives require a temperature of 140° C. to 180° C., hot-setting epoxy resins 100° C. to 240° C. Time required decreases as the temperature rises. At 240° C. a time of 10 minutes may be required, at 140° C. 7 hours. Of the many uses of adhesives some demand high temperature resistance, particularly the bonding of motor vehicle brake and clutch linings. Bonding gives longer life and one car owner whose riveted brake linings were worn out after 18,000 miles found that replacement bonded linings gave 52,000 miles' service. Adhesives have good resistance to ageing, illustrated by the long-term internal and external exposure tests of bonded lap-joints and experience of aircraft operating in tropical and other conditions. An important current use for adhesives is the bonding of stringers to skin and wings in such aircraft as the Canberra, Britannia, and Dove.[1]

[1] *Aluminium Courier*, No. 37, Mar., 1957.

* * *

After many years of research, Dr. Hubert Hildebrandt, of Kassel, Germany, has succeeded in establishing one of the world's stranger commercial products, animal-repellent scent. He has built up a stock of over 150 natural and synthetic scents, ranging from extra-strong "Lion 4" to the sweet smell of cherry blossom. As a psychologist Dr. Hildebrandt found that scents more than any other factor influence an animal's mental life, but only as a result of research work in testing stations throughout Western Germany was it possible to determine the exact reaction to particular scents. Lion 4 is one of the most recent achievements. When a South African farmer complained that hippos—too many to shoot—were causing havoc among his sugar plantations in Mtubatuba, Zululand, Dr. Hildebrandt's assistant went to the Berlin Zoo and made tests on the hippos there. He found that "Basic anthropine," a synthetic human sweat, had no effect. Tiger scent was unimpressive too. Lion 4 provided the answer and they fled. Anti-elephant scent has been tested in the National Park of Kenya, where the most effective scent was found to be a special blossom fragrance. Lion scent failed dismally on this occasion, though human smell results were good. In Scotch Village, Nova Scotia, a scent provided protection for one farm against porcupines. Human smell has been used to scare away stags from a Croatian farm, elks in Sweden, and other animals in Czechoslovakia and in Yugoslavia, where forests were being damaged, without shooting. An American firm has sought scents to protect cable installations from squirrels and a German firm asked for a preparation to impregnate its glass wool as a deterrent to nest-building mice. Near Altötting, Germany, anthropine is to be used as a protection for deer to prevent them from drowning in a canal. The market seems to be both wide and varied.

* * *

Many people grumble at the weather, while few make any attempt to modify its effects. Air-conditioning is one way in which something has been done. Since 1902, when Willis H. Carrier designed the first practical large-scale air-conditioner for a Brooklyn, New York, firm, it has become a commonplace and has contributed substantially to better working conditions and employee efficiency in many parts of the world. The most recent application is in Las Vegas, Nevada, where a drive-in coffee shop has provided air conditioning for the interior of patrons' cars. A central unit in the roof of the building is equipped with piping and air is delivered to individual cars by 6-in. flexible ducts hung over the parking spaces and pulled down by waitresses as required. The tube's nozzle is placed inside the window of the car and the air is deflected over the ceiling within so as to avoid any direct draught to passengers. A duct at the end of the system returns air to the central unit, ensuring a steady flow and delivery however great the demand.[1]

* * *

An American company is using a continuous process wire-plating system to triple plate four strands of wire at a time. The

[1] *Comp. Air Mag.*, Oct., 1957.

system takes the strands, usually manganese-nickel, through 12 cleaning, plating, rinsing, and drying tanks and finally rewinds them. Usually nickel strike, silver strike, and main silver plating operations are involved. Speed is normally 5 f.p.m. for each strand. A given point on a strand of wire will travel through the entire system in about ten minutes. Before the introduction of this system plating was done by a batch method in which wire coils were immersed in a series of solutions. This method gave little control over uniformity of thickness in the plating and outside surfaces could receive a heavy coating while inner ones received little or none. This created problems in the drawing of the plated wire to smaller sizes, since after drawing plating would be found to be below specification in some areas of the wire. These problems no longer arise. Plating thickness can be adjusted by varying the speed of the 2 h.p. motor which pulls the strands through the system by altering wire speed between 2 f.p.m. and 14 f.p.m. or by adjusting plating current. Plating thickness is uniform and consistent.[1]

* * *

The consumption of sample bottles in the petroleum industries having proved, in the case of at least one laboratory, alarmingly high, and the cleaning of the bottles by junior laboratory staff being less than efficient, the question of mechanizing the cleaning process so as to avoid wastage of bottles and time was investigated. Adaptation of the commercially available equipment to suit the 16-oz. (450 ml.) laboratory bottle was feasible and after trials with particularly heavily soiled bottles had proved satisfactory a machine was installed. The capacity is 720 bottles per hour and though designed for the standard size of 16-oz. bottles smaller bottles and even test-tubes can be processed. Some 60 jets of approximately $\frac{1}{8}$ in. diameter and $2\frac{3}{4}$ in. high are placed round a turntable, which revolves once every 5 min. The bottle to be cleaned is placed neck downwards over a jet and passes into a tunnel which consists of three sections. In the first of these sections a spray of white spirit, at room temperature, dissolves any residual oil adhering to the internal or external surfaces of the bottle. In the next section a hot aqueous detergent solution is used and finally, in section three, a hot water rinse. The bottle emerges close to the entry point and is removed by hand and placed in a rack. This rack is then inserted in a steam-heated drying oven, which forms a separate piece of equipment from the washing machine. Turntable and pumps are electrically operated, the total power consumption being 1,100 W. Steam and water as well as electricity connexions are required. White spirit is supplied from a drum by gravity and, since the 15–20 gallons used per 1,000 bottles washed can be returned to refinery slop, only redistillation costs are involved. The $1\frac{1}{2}\%$ detergent solution is held in a 17-gal. tank, which requires renewal, for bottles of average oiliness, every 1,000 bottles washed. Water consumption is about 100 gal. and steam 20 lb. per hour. Temperatures can be varied to suit conditions and so can the solvent and detergent wash. Over the greater part of a year a striking economy in bottle consumption has been shown, figures falling from 40,000 bottles (costing about £900) to 18,000 (about £400). Bottle washing, which used to occupy the full time of one junior, can be completed in $1\frac{1}{2}$ hours per day. Even more important for a testing laboratory the bottles are really clean. A very dirty bottle which does not yield entirely to treatment on the first round can be left on the machine and recycled, though this is not often necessary. Initial price of the machine was £700, to which cost of installation, solvent storage, drying oven, transfer racks, and other items must be added.[1]

* * *

Columbia University's Electronic Research Laboratory has made a significant contribution to radar science in the "tagged" signal continuous wave (CW) system developed there. Employing only conventional tubes and instruments this system makes a most efficient use of signal energy. By enhancing the signal and recognizing it at its return the CW system multiplies the effectiveness of conventional pulse radar. Range is increased tenfold, to about 2,500 miles ; precision of intelligence from the echo is increased even at maximum range. The importance of these advances in defence against long-range weapons such as the intercontinental ballistic missile (ICBM) is evident. Longer range gives longer warning. Greater accuracy means more precise prediction of target. Since the ICBM follows a fixed trajectory once the engines have burned out its velocity vector and location at the time of burn-out determine its course and timetable. Any error in their calculation at the beginning will be greatly multiplied by the end of the flight. Recent developments in

[1] *Automation*, Oct., 1957.

[1] *Inst. Pet. Rev.*, May, 1957.

Russia have intensified the search for an anti-missile missile and Columbia's radar may have an important contribution to make; if the new radar can be fitted into the nose of an anti-missile missile ICBM interception areas can be widely enlarged. The tracking of earth satellites and some phases of radio astronomy will also be assisted by these advances in radar science.

* * *

Pulse radar to-day derives its information from the amount of energy in each pulse. The time interval between pulse transmission and return determines distance, transmission absorbing about one-thousandth of that time. To increase the range a power increase is necessary. Energy is lost in proportion to the square of the distance, so to increase range tenfold a power increase of 10^4, or 10,000 times, is required. Columbia's system of Omni-Range Digital Radar (ORDIR) increases range by transmitting and receiving continuously in comparison to pulse duration. As much total energy is transmitted as in a pulse system, but it is spread evenly over the interval during which the pulse system first transmits, then waits for the signal return. The Columbia frequency—modulated 3,000-mc. carrier wave has been "tagged" for recognition on return. The wave is not deformed, but alternately crowded and spaced widely within a given time. Instead of relying on the return of the whole signal sent out during a microsecond, ORDIR breaks down the total signal into its component waves and obtains a more accurate set of measurements. Variations caused by such phenomena as the Doppler effect illustrate the improved accuracy of ORDIR's long signal over pulse radar's intermittent one. For a target moving at 1,000 m.p.h. the Doppler shift causes a rise in signal frequency of 10 kcps. In the pulse echo this is represented by two-hundredths of one cycle; with ORDIR the frequency change is magnified 70,000 times. Target velocity can thus be measured more precisely. The two most important factors in Columbia's achievement are frequency modulation which is more nearly linear than that achieved before and has 50 to 100 times higher signal stability. Because of its hypersensitivity the receiving unit is located miles from the transmitter. The experimental unit has achieved an efficiency, at over 90%, close to the theoretical limit.[1]

[1] *Aeronautics*, Oct., 1957.

News Letters

VANCOUVER

December 9.

Mining Taxation.—Strong criticism has been made of the British Columbia Government, following its announcement, in November, of the intention to make full application of the taxing powers provided in Bill 87 adopted by the legislature last spring. The Bill provides for a tax of up to 10% on ore in place and purportedly is to be applied only to iron ore, with the intention of encouraging the establishment of an iron and steel industry in British Columbia through its strong restrictive measures on the export of iron ore and concentrate.

The Mining Association of British Columbia, an operators' organization, has gone on record by forwarding a resolution to the Government in which the action is condemned. The position of the Association is that "such a tax will hamper the establishment of a steel industry in the Province by discouraging the search for new ore and the development of mines on which such industry depends." The British Columbia and Yukon Chamber of Mines has also condemned the action as providing for a levy in effect of "an excessive and discriminatory tax, on all iron ore mined, whether or not smelted in British Columbia. This legislation makes no provision for return of capital invested to bring a mine into production." The Chamber contends the legislation has had a serious impact on the whole of the mining industry and is curtailing all phases of prospecting and mining-exploration activity. With prospecting for iron-ore deposits at a standstill, the Chamber concludes that this abortive legislation has had exactly the opposite effect to its announced purpose. Instead of encouraging the establishment of a smelter within the Province "this Bill has had the effect of discouraging the efforts of prospectors and mine operators who were planning to search for additional ore deposits. It is considered by this organization that eventual establishment of a steel industry can only be achieved by full-scale exploration of British Columbia's iron-ore reserves."

Bill 87 is entitled the "Mineral Property Taxation Act" and is purported to provide for a tax on mineral property presently in production or that has been at some time in production. A spokesman for the mining

operators has interpreted the situation briefly as follows :—

From the regulations it is difficult to determine whether the new Act is really intended to tax mineral property or is a poorly disguised attempt to impose a further tax on the net value of mineral production. As far as potential investors are concerned, in any event, the difference is largely one of academic interest. Certainly the Act and the regulations provide for the arbitrary and discriminatory taxation of mining ventures under conditions that can only discourage further the development of the mineral resources of the province.

Mr. L. T. Postle, president of the Mining Association of British Columbia, has made the following public statement on the situation :—

There would appear to be a tendency on the part of political authorities to attempt to dictate as to how the product of the mineral industry is to be utilized. This principle was recently expounded by the International Union of Mine, Mill, and Smelter Workers and it has been attempted by the present provincial government in the case of iron.

The case of iron is interesting for there are relatively few known iron-ore bodies of anything but the smallest size in British Columbia. Much of this ore is of poor quality, containing impurities to an extent that would make the end product unacceptable to the steel industry in North America and Europe. Since the last war, the Japanese steel industry has been desperate for iron ore and consequently has been willing to purchase a relatively small amount of this impure British Columbia product. This apparently does not meet with the approval of provincial authorities and an effort is being made to stop the export of this ore.

The result is that an asset to British Columbia, not usable here, cannot be mined and sold abroad profitably. The worst effect of this attitude, however, is that there is almost no effort being put forward in the search for iron and the possibility of ever finding enough good iron ore to justify converting it into steel in the province is even more remote than it has been in the past. No one will spend money looking for iron ore if it must be sold according to the dictates of political authority.

Alberni.—Tofino Mines, Ltd., has announced its intention of commencing immediately on an underground-development programme at the Tofino gold mine, on Vancouver Island. The property has been opened by four adits over a vertical interval of 600 ft. and the depth persistence of indicated ore is approximately 1,000 ft. The company proposes to erect a logging-type skyline from the end of an existing road to transport materials and equipment to the portal of the lowest adit at elevation 1,500 ft. The present drive on the 1,500-ft. level was advanced by previous operators a length of 450 ft. and the advance was suspended with a face of good ore. Plans call for advancing this face for 1,000 ft. if the ore persists and the work is expected to confirm the persistence of ore developed at higher horizons. Ore reserves have been estimated by various engineers at 100,000 tons averaging 0·45 oz. of gold per ton or at 200,000 tons grading 0·32 oz. per ton. The present Tofino company, which is controlled by Moneta Porcupine Mines, Ltd., has made public its intention of developing a sufficient quantity of high-grade ore (in the range of 2 oz. of gold to the ton) to warrant extraction without awaiting more favourable conditions for gold mining. Privateer Mine, Ltd., then an important gold producer at Zeballos, acquired control of Tofino in 1947 and proceeded with most of the development work done on the property. Through a number of re-organizations necessitated to raise funds for continued work and assessment charges the name of the owner has been successively known as Tofino Gold Mines (B.C.), Ltd., Atlas Mining Corporation, Ltd., and now Tofino Mines, Ltd.

Vancouver.—A great deal of uncertainty exists as to the future of the copper-zinc mining and milling operation of Britannia Mining and Smelting Co., Ltd., a wholly-owned subsidiary of the Howe Sound Co., of New York. The company has experienced an operating loss over the past several months and last summer appealed to its employees to accept a 15% reduction in wages to reduce to some extent the overall loss being sustained. This proposal was refused, but at the same time some economies were agreed upon. Late in October the company again intimated it would be necessary to suspend operation if the operating loss could not be reduced. The situation was sufficiently serious to attract the attention of the Federal Government, with the result the Hon. E. D. Fulton, Minister of Justice, visited Britannia Beach and discussed the matter with company officials and with employees. Although no official announcement was made it was believed some agreement had been reached and that operation would be continued. Early in December, however, the company again announced its intention of shutting down and added that steps would be taken, commencing December 17, to suspend production unless it received some concrete evidence of consideration from the metal purchasers, the union, or the Federal or Provincial governments. The Hon. E. D. Fulton is again investigating the matter. Production

recently has been at the rate of approximately 4,000 tons daily with about 800 employees.

Lillooet.—Driving on the " 77 " vein on the 33 level of the property of Bralorne Mines, Ltd., in the Bridge River district, has disclosed the existence of some of the richest gold-bearing ore yet found in this highly-productive mine. The occurrence is also found at the greatest depth of any development in Western Canada, the Bralorne levels being separated by vertical intervals of 150 ft. In the first three rounds blasted since making contact with the vein the gold content has assayed in the " ounces " over a consistent width in excess of 6 ft. The cross-cut on the 33-level intersected the " 79 " vein in the course of the drive. That vein had a width of 1 ft. at the point of intersection with an indicated grade of ½ oz. of gold per ton. A drive is to be driven on the vein at a later date. The sinking of the Queen shaft has been continued on a two-shift basis. The 34-level station has been cut and the face of the shaft is now considerably below that horizon.

Cariboo.—The Cariboo Gold Quartz Mining Co., Ltd., is conducting a long drive on the 3,000-ft. level of the Aurum workings (previously known as the Island Mountain mine) to reach the Mosquito Creek fault zone. Surface indication gave promise of gold-bearing ore in this section and the present projected drive of 3,000 ft. is expected to reveal the depth-persistence nature of the deposition. The work is being carried on as a subsidiary operation to production which is being maintained at a profitable capacity. French Mines, Ltd., a subsidiary of Cariboo Gold Quartz, has reported an October production of 551 oz. of gold. The mill is currently treating 1,000 tons daily at this Hedley operation. New ore has been reported beyond the Cariboo fault in the driving of a new low-level adit. The work has been directed by the veteran consulting geologist, Mr. Paul Billingslye, of Burton, Washington.

Lardeau.—In the three-month period ended October 31, 1957, the last quarter of the company's fiscal year, Sunshine Lardeau Mines, Ltd., produced 723 tons of lead concentrate and 921 tons of zinc concentrate after the treatment of 7,777 tons of ore. Net smelter returns have been estimated at $183,936, of which $50,025 is profit before write-offs. Capital expenditures amounted to a net of $587 after receipt of an insurance claim and payment of $3,746 on the purchase of the Eclipse mineral claim. The economics of continued operation have been expressed as follows by the company president, Mr. J. A. Pike :—

Lead and zinc prices are now 13½ cents (since cut to 13 cents) and 10 cents per pound, respectively. The tariff hearings of the United States Tariff Commission, now being held, are of vital interest to Canadian producers of base metals, for the result will likely mean a reduction in their income.

Yukon.—The October production of the Yukon Consolidated Gold Corporation, Ltd., was valued at $250,000, bringing to $1,703,000 the year's aggregate to date. This compares with $1,605,000 for the full year 1956. Mild and favourable weather in Yukon permitted dredging to continue until late in November, with the result that a considerable addition will be made to the 1957 figures after cleanup.

TORONTO

December 27.

Gold Production.—The Department of Mines in Toronto reports that Ontario's producing gold mines milled 772,383 tons of ore during October having a content of 224,217 oz. of gold and 37,096 oz. of silver, valued at $7,657,426. There was an average of 11,087 wage-earners employed and the average grade of ore amounted to $9·91. Wright-Hargreaves Mines reported clean-up material from their mill as they are now having their ore milled at Lake Shore Mines.

North-Western Ontario.—Cordoba Mines, in which the Western Selection and Development Co., Ltd., has a substantial interest, reports excellent results from trench sampling in the copper-gold claims in Balmer township. A drilling campaign has been initiated based on the results, which were obtained after intensive field-work consisting of airborne and ground geophysical surveys, detailed geological mapping, as well as intensive trenching.

Saskatchewan.—The report of Eldorado Mining and Refining for 1956 shows a profit of $3,519,807. According to the president the income in 1956 totalled $45,504,290, including $20,785,781 derived from the sale of uranium concentrates purchased from other producers. Reviewing the Beaverlodge operation the president said that during 1956 production increased by 13% over the previous year owing to an increase in the tonnage treated, 20% of the available milling capacity being used for the treatment of 52,000 tons of ore

purchased from neighbouring mines. Underground work was concentrated chiefly in preparing the Ace and Verna mines for full-scale production.

Quebec.—In the first eight months of 1957 Quebec gold shipments totalled 666,453 oz., as compared with 721,458 oz. in the corresponding period of the previous year. The August output is given as 84,240 oz. The eight-month figure for silver is 2,426,009 oz., against 2,886,253 oz., the August, 1957, figure being 337,429 oz. Asbestos figures for the same period to August 31 last show an improvement over those for the previous year, being 640,779 tons, against 638,376 tons.

Officials of the Aluminum Co. of Canada, Ltd., the principal subsidiary of Aluminium, Ltd., said early in December that temporary repairs had been made to the electric power transmission line at Kitimat, B.C., and that power was again flowing into the town. Service to both the town and the aluminium smelter had been disrupted by a rockslide which knocked down one transmission line tower near sea-level about 22 miles south of the smelter. The loss of production was thought likely to be small.

Operations at Barvue Mines, north of Val d'Or, have been suspended owing to the low price of zinc. Open-pit work on the property, which is of low-grade, started in 1952. At December 31 last the ore reserves were estimated as 3,843,000 tons averaging 1·2 oz. of silver per ton with 2·5% zinc.

New iron fields are reported from the Hudson Bay area, where Malartic Gold Fields has a concession. The magnetite ore discovered so far sampled averages 40% iron, but is said to be of good concentrating quality. Associated in the exploration work are Wright-Hargreaves Mines and the Belcher Mining Corporation.

Geological Survey.—The Department of Mines and Technical Surveys in Ottawa announces that fundamental research into mineral formation is now receiving attention in the work of the Geological Survey. The improved prospecting techniques expected to result will aid in narrowing down the areas in which the deposits are most likely to be found. In the last five years the Survey has established three laboratories to carry on nuclear, geochemical, and geophysical research. In addition the Survey awards grants in aid to research workers in Canadian universities, these grants totalling $185,000 since 1951. This year 16 research projects are being supported in 9 universities. At the University of Toronto weathering effects on 25 minerals and 6 rock types are to be investigated, while at the University of Western Ontario tests will be made of the response of typical geological structures on electromagnetic prospecting devices. Interpretation of the readings of these airborne devices is difficult and these measurements should help solve the problem.

MELBOURNE

December 20.

Oil Exploration.—The Commonwealth Government is to provide a subsidy of £A500,000 to help the search for oil in Australia by private companies ; the subsidy will be directed toward stratigraphic drilling. The grant is to be administered on the following basis :—

Half the cost of each hole drilled to be paid by the Commonwealth and half by private enterprise.

The sites are to be approved by the responsible Minister after recommendation by his technical advisers.

Officers of the Bureau of Mineral Resources are to have access to the sites and be supplied with samples and all information obtained during drilling.

Scientific information obtained can be published by the Commonwealth 12 months after the drilling is completed.

In the past 50 years the sum of £A50,000,000 has been spent in the search for oil in Australia and Papua, New Guinea. More than £A33,000,000 of this amount has been spent since the discovery of oil at Rough Range, Western Australia, four years ago. The Government has assisted oil exploration indirectly through substantial concessions in income tax law and directly through the Division of National Mapping and the Bureau of Mineral Resources, the work of the Bureau having cost £A1,500,000 to date. Technical opinion is that there is no reason to assume that oil does not occur in commercial quantities in this country. The number of holes put down has been insignificant ; only about 400 have been drilled, about one-quarter of which have been relatively shallow. Since the announcement of the subsidy applications have been received from 11 companies and more are expected. Although assistance is to be given to speed the search the Government will discourage

haphazard drilling by speculative companies and the possibilities of success will be closely examined.

Several localities have shown oil occurrence either as seepage or as showings in bores, these localities being Lakes Entrance, Victoria; Roma, Queensland; Rough Range, and Kimberley, Western Australia; the Torrens Basin, South Australia, and in Papua. Santos, Ltd., which has been drilling in South Australia and south-west Queensland, has advised that representatives of the Delhi-Taylor Corporation have arrived in Australia to investigate areas held by the company and it is hoped that an association of interests will be established. Discovery of oil in quantity in Australia is of great importance. Diesel power is advancing very rapidly, particularly on the railways, and any interruption to importation of supplies would have very serious results to transport, particularly if steam locomotives are scrapped instead of being stored, and the effect upon agriculture, in which tractors now play a very large part, would be disastrous.

Tin Dredging.—Australia's largest tin producer is Tableland Tin Dredging, at Mount Garnet, North Queensland. After the company had exhausted its original area the dredge was moved to new ground some miles distant. Subsequent results have been erratic, yields varying considerably. In the year to June 30 last a loss of £A29,006 was made, as compared with a profit of £A133,510 in the 1955–56 period. Tin oxide concentrate produced amounted to 544 tons, or 244 tons less than in the previous period, resulting in a fall in sales revenue of £A146,655. Costs rose by 4·61d. to 22·76d. per cu. yd.

The result has been caused by the erratic distribution of the runs of values, but since June conditions have improved considerably and improved recoveries have been made. These uneven conditions do not seem to have been apparent from the boring of the property. An improvement in the cost position will result from the purchase of electric power from a Government hydro-electric undertaking on the east coast at Tully Falls. This became available in July and the company was then able to close down its own diesel-operated power plant at the mine.

The country's production of tin will be helped by the operations of Ravenshoe Tin Dredging in the same district, Mount Garnet. The leases are at Battle and Nettle Creeks and are extensive. Commencement of dredging was delayed until purchased electric power was available and work was commenced on September 3. In the first four-weekly period production was 20·8 tons of tin oxide concentrate and output should improve. Capital of the company is £A399,807 and an overdraft of £A313,440 has been guaranteed by the Queensland Government.

Westralia Mount Morgans.—The old Westralia Mount Morgans mine was an important gold producer in Western Australia from 1897 to 1931 and in subsequent years some gold recovery has been made from tailings re-treatment. The mine is situated at Morgans, in the Mount Margaret Goldfield north of Kalgoorlie, and in recent years there has been increasing opinion that the property should be diamond drilled. No drilling was done in the mine's active years, but is about to be commenced by Western Australian interests. The orebody is in an extensive banded jasper formation and renewed interest has been stimulated by the success in the deeper levels of the Hill 50 mine at Mount Magnet, which is also in banded jasper. The main shaft is down to a depth of 670 ft., but the orebody has not been worked below 370 ft. excepting some crosscutting at the 500-ft. level. The mine was originally worked by an English company. Recorded production from the mine was 773,736 tons of ore for the recovery of 352,305 oz. of gold, exclusive of subsequent recovery from sands retreatment. The operations of the English company are reported to have produced 304,517 fine oz. of gold from 597,640 tons of ore, valued at £1,293,500 with gold at £4 4s. 10d. per oz., and £226,822 was paid in dividends. The lode consisted of parallel quartz lenses within a width of 100 ft., the maximum development being at the 200-ft. level. Length of the lodes aggregates 4,000 ft.

The diamond drilling is to be carried out by the Department of Mines and the operation will be one of major interest. East of the Morgans mine is the old Lancefield mine which is one of the best prospects in Western Australia. A recent re-opening showed important extension of ore longitudinally and vertically with good width and a grade of 7·5 dwt. Operations were unfortunately halted by inadequate capital.

Tennant Creek.—The Northern Territory's big gold mine, Australian Development, earned the record profit of £A489,608 in the year to June 30 last; the previous year's profit was £A388,772. Dividends since the

commencement of mining by the company total £A2,943,750. Ore treated during the year was 30,112 tons for a return of 42,495 oz. of gold ; tailings re-treated during the period amounted to 13,688 tons from which 8,898 oz. of gold were recovered. Mine development more than equalled ore extraction. Positive ore reserves are estimated at 142,000 long tons, with an average value of 28·5 dwt. gold. Ore has not been located much below the 300-ft. horizon, but lateral exploration continues to locate satisfactory occurrences of new ore. Hitherto gold has occurred in, or in proximity to, hæmatite, which itself is not auriferous, but recently orebodies have been found in chloritic schist, which is considered an interesting and valuable feature in development. As a result of recent surveys by the Bureau of Mineral Resources two adjacent areas have been pegged by the company.

Asbestos.—Western Australia has very extensive deposits of crocidolite in the Wittenoom region of the State, inland from Roebourne. Extensive development and equipment has been carried out by the Colonial Sugar Refining Co., of Sydney, through a subsidiary—Australian Blue Asbestos, Ltd. The greater part of the fibre is exported. Operations have been expanding and in the first nine months of 1957 sales were at the rate of 12,000 tons of fibre per year, valued at £A1,200,000. To meet the increasing market for the product the company is erecting additional plant, the first section of which should be in operation about the middle of 1958. The extent of the asbestos-bearing country is very great ; the fibre occurrences are horizontally bedded, associated with quartzites and limestones, and are exposed in the sides of gorges, some 400 ft. to 500 ft. deep, being located midway in the depth. Mechanized mining is practised underground.

In the Eastern States asbestos is found mainly in New South Wales, where chrysotile of high grade is being mined. A large part of the country's requirements is imported, but imports could be reduced probably by greater attention to the local occurrences.

Hill 50.—This Western Australian mine at Mount Magnet is the State's richest gold producer and reached this position comparatively recently after many years as a borderline mine. In the year ended June 30 last the company earned a profit of £A922,544, as compared with £A903,436 in the previous year. Dividends and bonuses paid during the year amounted to £A1,125,000. Ore milled in the period was 124,155 short tons and gold recovered was 87,204 fine oz. Ore reserves are estimated at 713,000 tons with an average value of 12 dwt. gold per ton, equal to rather less than five years' supply to the mill at the present rate of extraction. Development has reached the 1,300-ft. horizon, where the ore-shoots, particularly at the north end, are of lower grade than at the 1,060-ft. level. The reduction in grade of ore will necessitate an increase in output of ore and by mid 1958 this will be raised from 9,300 tons to 12,000 tons per four-weekly period. Prospecting will be pressed on ; 15-dwt. ore has been located in the north end at the 130-ft. level which hitherto has been a barren zone in the upper levels.

The success of this mine, which followed exploration below the 600-ft. horizon, led to a considerable boom on the Mount Magnet field, abandoned mines being re-examined at great depth, in all cases unsuccessfully, although recently the Eclipse mine has been floated on an ore tonnage of 17,000 tons of 35-dwt. ore above a depth of 475 ft. Despite the disabilities of gold mining and the small tonnage the venture was well received. With an adequate price for gold a substantial revival in Australian gold mining could be expected.

Bulolo Gold Dredging.—This famous New Guinea company is nearing the end of its life. Reserves of gravel are estimated at 22,662,000 cu. yd., of which 11,487,000 cu. yd. are dredgeable and the remainder, with an average grade of 11·7 cents per cu. yd., will be sluiced. One bucket dredge only is now working out of the original fleet of eight in the big years. Hydraulic work continues satisfactorily and it is stated that with the low costs of this work gravel reserves may be substantially increased.

In association with Clutha Development, Ltd., a number of areas in Papua and New Guinea have been taken up and are being prospected for nickel and other metals. Information cannot yet be given on results. The company has entered into the logging and sawmilling industry and this is expected to earn satisfactory profits.

Gold.—Figures issued by the Commonwealth Bureau of Statistics give the Australian mine production of gold for nine months to September 30 last as 806,959 fine oz., which is an increase on production for the same period in 1955 and 1956. In

August, 1957, production was 86,376 fine oz. and in September, 87,286 fine oz. Monthly averages of production were 87,420 oz. in 1955 and 85,818 oz. in 1956. Government subsidies paid to producers—in the borderline class—were £A236,946 in 1955; £A596,161 in 1956, and £A219,576 in the nine months of 1957, January to September.

Central Norseman.—Developments at Central Norseman Gold Corporation, Western Australia, continue very satisfactorily. In the Regent Shaft area the centre of interest is still the Crown Reef. At No. 14 level the north drive was advanced 140 ft. to 1,477 ft.; assay values from 1,337 ft. to 1,449 ft. were 24·7 dwt. over a width of 48 in., with low-grade material beyond that distance. Two rises from the level were in ore averaging 9·6 dwt. and 5·5 dwt. over 48 in. At No. 15 level the north drive was extended 195 ft. to 1,289 ft. in ore of an average value of 35·6 dwt. over 59 in. Development on the Mararoa Reef and in the Princess Royal section seems to be in abeyance for the time being. The Corporation has a substantial future on good-grade ore.

North Queensland Bauxite.—The Queensland State Government has insisted on export restrictions in the agreement with Commonwealth Aluminium Corporation with regard to the working of the immense bauxite occurrences on Cape York Peninsula, taken up and explored by the Zinc Corporation group. The restriction is stated to be as a guarantee for the construction of a raw bauxite treatment plant. The Minister for Mines has described the undertaking as one of the biggest by any company in Australia, apart from the Snowy Mountains hydro-electric project in New South Wales, which, however, is not a company venture. Commonwealth Aluminium Corporation will spend over £A40,000,000 on a harbour, a township to accommodate 5,000 people, and an alumina production plant. In 20 years' time it is expected that a decision can be made as to whether it is economically possible to erect a £A125,000,000 aluminium smelter in Australia or its Territories to produce at least 30,000 tons of aluminium per year. Under the agreement export under the restrictive clause, except to the Bell Bay aluminium plant in Tasmania, must be approved by the Governor-in-Council, for it would be unreasonable not to allow export by the Corporation for a period, provided it was taking necessary steps to build its own plant.

JOHANNESBURG

December 28.

Finance and General.—According to the South African Reserve Bank the Union's monetary volume of economic activity increased at a higher rate during the first ten months of 1957, particularly since the end of March, than during the previous two years. From the second to the third quarter deposits with the commercial banks rose sharply, import values increased substantially, especially in motor-cars, and there were notable advances in commercial bank discounts and advances, export values, railway earnings, property transactions, and building plans passed. (Since then other reports have taken a less optimistic view of immediate future trends.) Owing to the relaxation of import controls, however, there was a substantial rise in the value of imports in the third quarter and a consequent deterioration in the balance of trade. Over the first nine months of the year, on the other hand, the trade deficit increased only slightly compared with 1956 and, in fact, an improvement in the current deficit of the balance of payments was noted. The former amounted to £90,000,000 and the latter to about £4,000,000, respectively, as compared with £89,000,000 and £13,000,000 in the corresponding 1956 period. Increased gold and uranium output and exports in 1957 were principal factors in both balances.

The Ore and Metal Co., Ltd., a subsidiary of the Associated Ore and Metal Corporation, Ltd., has been appointed sole sales agent, distributor, and shipper to Feralloys, Ltd. Associated Ore will be a substantial shareholder in the Feralloy company, the initial objective of which will be the production of ferro-manganese; another associated company—the Associated Manganese Mines—will supply both manganese ore and iron ore, the latter being intended for a possible later production of pig-iron. African Mining and Trust Co., Ltd., the principal subsidiary of the Associated Ore Corporation, is also a substantial shareholder in the Feralloy company and has been appointed the latter's technical advisers. In the Associated Ore group Krantzberg Mines has had its prospecting claims in the Omaruru district, South-West Africa, converted into mining areas over 2,400 hectares, but due to tungsten price trends mining operations have been

placed on a caretaking basis pending a recovery in prices. Another group company, Associated Asbestos, Ltd., producing crocidolite in the Pietersburg asbestos belt, has increased its base-metal claims to 6,267 through the acquisition of a further 527 and has mining rights over about 2,111 acres, all in the same area, where it also has secured options over other claims : asbestos output is expected to be raised further. Initial output of abrasive stones for testing purposes is now being considered by the Transvaal Corundum Co. Wonderstone (1937), Ltd., is organizing expanded output to meet keener export demand.

Marginal Mines.—The committee (or conference) consisting of representatives of the Government and the Department of Mines, the Gold Producers' Committee of the Chamber of Mines, the associations of mine officials, and the Mining Unions' Joint Committee, have completed their deliberations and their report on the problems of the marginal or vulnerable mines. This report, now being considered by the Government, noted possible measures for prolonging the lives of such mines and staggering their closing in order to minimize unemployment and attendant dislocation in the relevant organized areas. Further details are not yet available.

Iron and Steel.—The South African Iron and Steel Industrial Corporation, Ltd., is continuing its policy of appropriating substantial amounts from profits for its replacement reserves, necessitated by the high costs of new equipment. The current programme of expansion and, generally, alterations, additions, improvements, and modernization are being financed as far as possible from retained earnings, specific reserves, and provisions (to the extent that the latter are not immediately required for their primary objectives). Accordingly, considerable cash resources are being built-up. The corporation has reviewed its expansion programme in the light of more recent information and has decided to raise the rated output capacity by about 900,000 ingot-tons a year, instead of the previous figure of 550,000, to a total rated capacity of about 2,350,000 ingot-tons a year at its Pretoria and Vereeniging Works. This will mean a further extension of the programme of expanded operations at the Sishen iron-ore deposits (Kimberley-Postmasburg area) and securing additional supplies of such raw materials as coal and coke, limestone, dolomite, fluorspar, etc., improving techniques, extending research, and providing better educational and training facilities for staff and increasing office accommodation. The selection of a site for a future third steel works continues to engage the attention of the corporation.

Transvaal.—Msauli Asbestos Mining and Exploration has obtained outstanding success from an experimental plant, erected at considerable cost, and designed to give a specialized blending of the run-of-mine fibre product. This blended product has realized higher prices and earned a steady market. The new vertical shaft has been completed for operational purposes and the new hydro-electric scheme was scheduled for commissioning for trial runs by the beginning of December. Drilling operations have disclosed a payable block of good-quality fibre in a zone adjoining the larger of the company's two mills. Quarrying is expected to be initiated by about mid-1958.

Despite intermittent shortages of underground labour in certain categories Witbank Consolidated Coal Mines succeeded in advancing sales output steadily over its past three years, from 399,464 and 420,393 to 469,716 tons. As far as the company's operations were concerned the railway transport position has improved slightly but remains below requirements.

While operating results of the wholly-owned subsidiary of Carrig Diamonds, Ltd., declined somewhat in the year to June 30 at 70,167 tons washed and 100,814 carats recovered (as compared with 74,268 and 113,520 respectively) they remained satisfactory. Difficult underground conditions were again experienced and increased costs by 20·1% to 54·17 shillings a ton. Ore reserves were not quite maintained, but mining in the difficult shale zone is expected to continue at least for another year. In the meantime returns should benefit from the sorting station being erected and the incorporation of wet screening facilities in an extended washing plant and from economies derived from the supply of electric power from the Electricity Supply Commission network.

Rustenburg Platinum Mines, in the face of the pronounced weakness of the platinum metal market, the excess of supplies, and easier metal prices, has taken steps to reduce output in the 1957–58 year to about 60% of the previous year's production. In the 1956 calendar year 484,574 oz. of platinum-group metals were produced, of which 330,316

were sold. The 1957–58 appropriation from profits for capital expenditure, already to be incurred, will be substantial and with revenue expected to be much less dividends should consequently also be considerably reduced from the 1956–57 levels. This applies as well to the holding companies, Waterval, Union, and Lydenburg Platinum, and Potgietersrust Platinum. Mining leases have been secured by the Rustenburg company over an additional 5,166 claims, but signature of the agreements had not been effected by the financial year-end, commissioning of the new Rustenburg Section reduction plant has been deferred, but it has not yet been announced whether the additional smelting capacity will be similarly dealt with.

Zaaiplaats Tin Mining has installed a bank of spirals for the treatment of mill tailings. Arrangements have been concluded for the purchase of electric power from the Potgietersrust Municipality, which should be made available in the new year and accordingly no major items have been added to the existing generating plant. The company's refinery produced about 1,677,000 lb. of ingot tin in the 1956–57 year. The Stavoren section has been equipped and in time may counterbalance loss of output from the Roodepoort lease area, where operations have been suspended although exploratory work is continuing.

Recent development at the Buffelsfontein mine has disclosed a narrowing of the reef eastwards, which may necessitate an increased sorting rate in order to maintain the grade and a higher mining rate in order to maintain the treatment tonnage. However, the programme of expansion, which is expected to be completed in the second half of 1958, provides for increasing the gold plant capacity to 150,000 tons monthly, as compared with the present treatment rate of 110,000, as well as raising capacities in the uranium, pyrite, and acid plants. These advances will be accompanied by an expansion of underground operations. So things in general should more than even out. In any event the overall hoisting capacity is also being increased and the ventilation shaft is being re-equipped with a 5,000-h.p. winder to handle the additional tonnage.

Operations are being expanded in gold-bearing deposits about 11 miles from Letaba, north-eastern Transvaal, originally exploited about 60 years ago. High values were then obtained and according to a recent announcement of the operating company—Inyoni Mining and Exploration—have been obtained in limited operations to date. Results from the property, which extends about 7½ sq. miles, will be watched with interest.

The Phosphate Development Corporation (Pty.), Ltd., which, for a longer time than was originally intended, diverted the use of its pilot flotation plant to test runs on the low-grade copper ore in its property and thereby gained valuable information on actual process requirements for the future evaluation of the ore reserves held by it, returned the plant to the concentration of the igneous phosphate ore earlier this year and has reported profitable operations. However, since the unit is only a pilot plant, expanded operations will be necessary for earning adequate returns. One of the operating difficulties has been the daily variations in grade, but there are indications of greater consistency at depth. A fourth quarry is being opened up, making, with the other three, 1,500,000 tons available for mining without further development. To date the corporation has concentrated its operations on treating a 10% P_2O_5 grade but large reserves of a 5–7% P_2O_5 grade are additionally available, which the corporation has shown can also be economically treated.

Orange Free State.—In a review of its project and its component units the South African Coal, Oil, and Gas Corporation reports that to the present the American synthesis plant has unfortunately averaged only between 30 and 35% of its designed production rate, the major factor in the operational difficulties. Of the total of nearly £40,000,000 expended on facilities required to produce oil from coal and to market products, 82·6% has been spent on plants running smoothly and capable of capacity operation or better and on ancillary assets, including the German oil synthesis plant, the coal mine, external services, steam and power generation, oxygen production, gasification, gas purification, and various installations dealing with final products.

Cape Province.—South African Manganese, Ltd., in the year to June 30 strengthened its capital reserve for the acquisition and development of additional properties from £425,000 to £675,000 in order to finance the opening up of a new mine in the Kuruman district. Stripping the overburden has already commenced and production is expected to be initiated by about mid-1959.

Ore from this new deposit, proved to be large and of a grade suitable for export and domestic requirements, will be moved along a rail extension from Sishen, or failing this by an expanded fleet of heavy road vehicles. The company has concluded a long-term contract with its associated African Metals Corporation for the supply of manganese ore for the domestic production of ferro-manganese, which will absorb increasing tonnages in the near future.

Southern Rhodesia.—At M. T. D. (Mangula), Ltd., concentrates are already being shipped overseas, but at a later date it is expected that a smelter will be erected on rail in the vicinity of the mine. Special interest attached to the mill, which incorporates a 22-ft. Aerofall unit and a regrind mill and is expected to reach a milling rate of 1,700 short tons a day in the first quarter of next year, giving an annual output of 14,400 short tons of concentrates (with an expected copper content of the order of 50%). This milling unit is being duplicated and the milling rate will thereby be raised to 3,000 short tons of ore a day in the first half of 1959.

South-West Africa.—Maintaining that the company owned the mining rights over the 180-mile long coastal strip between high- and low-water marks between the Orange River mouth and Luderitz, Consolidated Diamond Mines of South West Africa, Ltd., failed in its petition for a court declaration in its favour and is appealing against the High Court ruling. This ruling therefore supported the granting last year by the Administration of the mining rights over the strip to Suidwes Prospekteerders (Pty.), Ltd. In the hearing, the Administration maintained that the Consolidated Diamond Mines rights extended only down to the high-water mark. In 1923 the latter company was granted by statute exclusive rights over a 10,000 sq. mile diamond area defined as the Spergebiet (prohibited area), which the respondents, the Administration and the Suidwes company maintained, was clearly proclaimed as excluding the strip. The Court found that, while for security and other reasons it was desirable for the Consolidated company to own the rights down to the low-water mark, this did not empower the Court to insert into the proclamation words giving another conception than that intended.

Tanganyika.—Tanganyika Diamond and Gold Development has derived very beneficial results from the new scrubber recently installed ; oversize rejection is now negligible and the operation of the pans is more efficient. The company will retain an interest in another company to be formed for exploiting the Lichtenburg diamond deposit, previously mentioned.

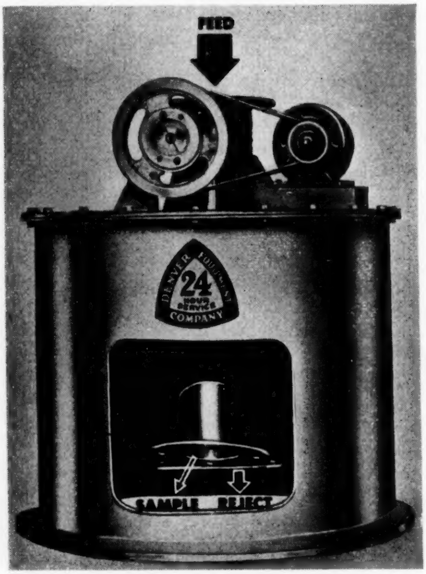
The Mbeya Exploration Co., Ltd.—jointly owned by N.V. Billiton Maatschappij and the Colonial Development Corporation—is operating a 9-ft. Aerofall mill in its pilot plant at the Panda Hill niobium-bearing pyrochlore deposit, with a treatment rate of 150–200 tons a day.

Trade Notes

Brief descriptions of developments of interest to the mining engineer

Vezin-Type Sampler

A new design of Vezin-type sampler, as illustrated, incorporates a cylindrical housing to give a more compact unit. It is intended for sampling material continuously and one or more radial cutters are attached to a revolving vertical cylinder and shaft inside a dust-tight sheet-metal housing, so that at the correct speed they allow the sample to enter the cutter without interference. As the cutter passes under the discharge end of the feed chute a sample is cut from the stream and conducted by a pipe or chute to the units which reduce it in size or prepare it for further sampling or testing, rejects falling into the hopper and being returned to the circuit. It is available in a range of sizes from 20 in. to 60 in. in simplex, duplex, or multiple units. As an example a standard duplex unit takes a



10% sample, mixes it, and feeds to a secondary sampler which in turn takes a 10% sample, thus giving a final sample of 1%. These notes are supplied by the makers, **Denver Equipment Co.,** of Denver, Colorado.

Laboratory Hydrocyclone

The hydrocyclone was described in the MAGAZINE in February, 1956, and in August of that year some notes were given on the multi-hydrocyclone. The same company—**Liquid-Solid Separations, Ltd.,** of 2, Anderson Street, London, S.W. 3—now draw attention to a laboratory test set which is available. This, which is shown in the illustration, consists of 15 mm. and 30 mm. diameter hydrocyclones in "Pyrex," each with three interchangeable vortex finders and five interchangeable apex nozzles of different diameters fitting by means of precision-ground glass joints and is complete in a polished wood case (nett weight 3 lb. and gross weight 8 lb.). Auxiliary equipment required consists of a suitable pump capable of about 4 g.p.m. against 100-ft. head fitted with a delivery pipe incorporating a Schaeffer (diaphragm type) pressure gauge and a by-pass valve for controlling feed pressure, together with a conical pump sump over which the Hydrocyclone can be suspended and into which it can discharge its product for reconstitution and recirculation if desired. Spares are readily available if required but in practice are rarely needed.

Liquid-Solid Separations Laboratory Set.

Personal

D. G. ADAM is now with Giant Yellowknife Gold Mines.

J. H. BENNIE has left Canada for Malaya.

T. H. BRADFORD has been appointed a director of Rhodesian Selection Trust, Ltd., Roan Antelope Copper Mines, Ltd., and Mufulira Copper Mines, Ltd.

K. M. COLLINS is home from Nigeria.

M. EICHELBERGER, recently with Geophysical Service, Inc., has joined the Aero Service Corporation of Philadelphia.

D. A. ETHEREDGE has been appointed a director of Chambishi Mines, Ltd.

G. H. FAIRMAID, who has left on a visit to New Zealand, has ceased to be chairman and managing director of Pahang Consolidated, but remains a director; he is succeeded as chairman by J. N. DAVIES.

A. R. C. FOWLER has been appointed an assistant consulting engineer of Rand Mines, Ltd.

I. GOLDBERG has left for Southern Rhodesia.

F. G. HAMILTON is now with Rio Tinto Australia Exploration Pty., Ltd., stationed in Tasmania.

PETER L. HOOPER has left for Canada.

CUTHBERT JOHNSON, manager of the Mond Nickel Company's precious metals refinery has retired; he is succeeded by A. R. RAPER.

E. G. KEARNEY has left Northern Rhodesia for Canada.

DONALD M. LIDDELL, a partner for 17 years in the firm of Weld and Liddell, engineers and economists, has been awarded the gold medal of the Mining and Metallurgical Society of America for 1957 for outstanding contributions in the field of non-ferrous metallurgy and research.

R. A. MACKAY has left on a series of professional visits to the Middle and Far East.

P. E. MOLYNEUX is returning from Sierra Leone.

H. L. MONRO has been appointed a director of the Union Corporation, Ltd.

G. C. NORMAN is returning from Ghana.

RALPH D. PARKER, vice-president in charge of Canadian operations of the International Nickel Co. of Canada, Ltd., is to move his headquarters from Copper Cliff, Ontario, to the company's offices in Toronto early in this year.

J. PENHALE has left for Sierra Leone.

G. G. POTIER has been appointed a director of the Consolidated Gold Fields of South Africa, Ltd. and of New Consolidated Gold Fields, Ltd.

W. T. ROBSON has been appointed general manager of Lake Shore Mines.

G. A. SCHNELLMANN has returned from a visit to Egypt.

D. SIMMONS, of Mackay and Schnellmann, returned recently from Cuba and left immediately for Persia.

K. L. SUTHERLAND has been awarded the H. G. Smith Memorial Medal by the Royal Australian Chemical Institute.

SCOTT TURNER, formerly director of the United States Bureau of Mines, has been awarded the Hoover Medal for 1957.

F. G. VOGWILL has left for Ghana.

CLIFFORD WAITE has been elected president of the British Overseas Mining Association and A. V CONRAD, vice-president, for the ensuing year.

W. G. YUILL, of Mackay and Schnellmann, has recently returned from Persia.

JOSEPH AUSTEN BANCROFT died in Johannesburg on December 13, aged 75. Formerly Darwin Professor of Geology in McGill University Dr. Bancroft had been associated with the Anglo American Corporation of South Africa, Ltd., for over 30 years, being largely responsible for early exploration work in Northern Rhodesia and the Orange Free State. He was a Gold Medallist of the Institution of Mining and Metallurgy.

HARRY CHRISTOPHER GANT died in London on December 7, aged 61. Mr. Gant had been associated with Cyanamid of Great Britain, Ltd. (formerly Cyanamid Products, Ltd.) for over 37 years and had been a director of the company since 1927. He was largely responsible for the early introduction of the products of the American Cyanamid Company to British users and for the purchase of a large volume of chemical products in this country for American Cyanamid Company.

Metal Markets

Year-End Review [1]

Copper.—Price fluctuations [2] in December were over a pretty limited scale, but even so prices have managed to slip during the course of the month to the lowest level recorded in post-war free-market trading—£176 per ton. It is always rash to predict future copper price movements, but it is possible to suggest that prices will probably not go much lower. Although there is no strength in the market as the year ends and prices are only a few pounds above the worst, it seems inevitable that the market must have derived some benefit from the production cuts which have been announced since the level of £176 was seen. Most important of these undoubtedly has been a cut of 12% at some of its more important operations by Kennecott Copper Corporation, although subsequently Cerro de Pasco and the Howe Sound Co. announced that they, too, would make cuts. The cut made by Kennecott has a particular technical significance as it clears the way for a deliberate cut by the big producers in Chile. Under Chilean law these companies are not allowed to cut output by more than the amount that their principals in the U.S.A. have cut theirs. Now that both Kennecott and Anaconda have announced formal output cuts the way is clear for reductions in Chile to take place. As this report is being written it is rumoured that such reductions may be permitted although in view of the political

[1] Recent prices, pp. 8, 48.
[2] See Table, p. 48.

and social implications behind any such action in Chile it is perhaps permissible to adopt a cautious attitude.

Two Governments have made announcements on releases of copper from strategic stocks. The U.K. authorities have again deferred starting the release of the 27,000 tons which are still available for disposal, while the Italian Government finally announced officially that it would make a stockpile disposal but said that the rate—approximating 400 tons a month—would be substantially less than the market originally feared.

The outlook for 1958 shows one or two bright spots—mostly of a long-term nature—and the most that can be hoped for in the near future is that the long pull back to better prices will begin as soon as possible.

U.K. copper consumption in October amounted to 49,638 tons of refined and 10,410 tons (content) in scrap; production was 9,257 tons primary refined and 8,699 tons secondary refined. Stocks registered a decline from 81,211 tons to 73,489 tons.

Tin.—December has been a most significant month in the tin market,[1] as it saw the introduction of some extremely heavy cuts in the exporting potential of the producing countries who are signatories to the International Tin Agreement. Owing to the technicalities of the agreement different countries are affected differently, but an important producer such as, for example, Malaya will have to cut exports by about 32% while the average for all producers is $28\frac{1}{2}$%.

There have naturally been some fairly distressed cries from the producing countries as the cuts have upset a good many national economies, especially those that are not too well diversified. However, perhaps the most telling evidence of the need for such drastic cuts is the fact that up to the end of December prices have only maintained themselves at the Buffer Stock's minimum level and the shortage, which it is still statistically correct to anticipate, has not been reflected in advance at all. This is particularly important when it is remembered that the market has received some support from persistent labour trouble at the Penang tin smelter of Eastern Smelting, as well as from the political upheaval in Indonesia which now seems definitely to be affecting shipments of concentrates.

U.K. consumption in October was 1,947 tons and production of primary metal 2,899 tons. Stocks were slightly lower at 6,045 tons at the end of October.

Lead.—There have been no basically new features in lead in December and although the implications of the possibly higher U.S. tariffs in a month or two's time have now been completely discounted there is no indication that the market has any inherent resistance to lower prices.[1] It now seems to be definitely established that purchases by the U.S. Government of U.S.-produced lead for the stockpile will be terminated as soon as the proposed increases in the tariff may be recommended and approved.

One of the main causes of weakness has been the continued release of metal from the U.K. Government's strategic holdings, which was announced early in the month, although it is certainly true that the rate of release is not now as high as previously—some 1,200 tons a month against 3,000 tons formerly.

[1] See Table, p. 48.

U.K. consumption in October amounted to 32,486 tons, with production of English refined 7,788 tons. Stocks rose rather sharply to 50,317 tons.

Zinc.—Sentimentally, there is now little to choose between the lead and zinc markets,[1] although on the basis of the factual and statistical position the position of the latter seems the less desirable. As lead and zinc are so intimately connected in the mining phase there is not much opportunity to restrict output of the one without the other, so that although a certain amount of output cutting is called for in both cases lead considerations might inhibit introducing the full cut called for in the case of zinc. At the moment mines are holding their offerings of concentrates down to the most reasonable level, but this, of course, is not the same thing as actually producing less. It is to be hoped that by the end of 1958 the general economic position of the world—and especially the U.S.A.—will have begun to show some signs of recovery, but until then it would be folly to take other than a serious view of the outlook for zinc.

U.K. October consumption was 29,552 tons, so that the ten months' total is 265,282 tons against 266,199 tons (revised) in the same period of 1956. This emphasizes the extent to which the weakness of the American market is responsible for the global statistical position.

Iron and Steel.—The United Kingdom steel industry entered 1958 with much quieter conditions prevailing than was the case a year ago. Since October output has been falling gently and 1957 production is expected to be around 21,750,000 tons of ingots and castings against a possible 22,300,000 tons. Moreover the estimates of 1958 production have been revised. Against a possible 23,500,000 tons to 23,750,000 tons an actual production of between 22,000,000 tons and 22,250,000 tons is thought likely.

The reasons for the decline have been basically the credit squeeze—resulting in reduction of stocks—coupled with similar restrictions in many other parts of the world and the enormous increase in both U.K. and world steel output capacity. The products most seriously affected have been tinplate and light sections, but there are signs that several other items are also becoming more easily obtainable and although it is possible that shortages of plates and sheets may persist in 1958 most other products are expected to be freely available.

Imports were drastically reduced during 1957, the bulk of them comprising pig-iron, semis, sections, sheets, and ferro-alloys and final figures will probably show a total of around 1,300,000 tons (2,123,000 tons in 1956). A further decline will occur in 1958.

Considerable achievements have been recorded on the export markets, overseas shipments being boosted to new heights. The final figure for 1957 will probably be in the neighbourhood of 3,200,000 tons of iron and steel compared with 2,825,000 tons in 1956.

Conditions are obviously going to be harder for the steel trade in the coming year, but nevertheless the industry is pressing forward vigorously with its expansion plans.

Iron Ore.—Arrivals of iron ore in the first eleven months of 1957 were a record at 14,794,354 tons

[1] See Table, p. 48.

against 13,289,163 tons in the corresponding period of 1956.

Aluminium.—December was not a tremendously active month for the aluminium market although one notable event occurred on December 23. This was the pouring of the first metal from the new reduction plant of the Canadian British Aluminium Company at Baie Comeau, Quebec. This event marked the completion of the first of four production stages of the £50,000,000 plant which will eventually have an annual capacity of 160,000 tons of ingot. The starting up of this plant is a considerable achievement as it was less than two years ago that work on site clearing began.

While there were no price alterations at the end of 1957 there were people who were convinced that there would be and they could possibly have been right if it were not for the price concessions offered by producers in the form of rebates for metal bought over a period and the lowered extras on some primary forms.

Russian metal continues to be in the news and it may be worthwhile to make a comment similar to that in our previous report regarding the prices at which this material is offering. While the majority think in terms of £185 a ton when discussing metal from Soviet sources it must be borne in mind that sales are being made at down to £183 a ton, with offers to the larger and more important customers and potential customers at around £181 a ton. How low the Russians are really willing to go with their prices remains to be seen, although it may be that the lower quotations are indicative of hard bargaining on the part of consumers. In addition to this, Russian metal is finding itself in competition with aluminium from the same source but being offered by " middle-men."

Another point of interest during the month was the rumour that the London Metal Exchange was considering the introduction of a futures contract in aluminium. However, nothing more concrete has emerged from this rumour.

The price of aluminium in the U.K. remains at £197 a ton.

Antimony.—While once again the antimony market showed no startling moves or alterations it is interesting to note that during November some 1,182 tons of antimony ore and concentrates were imported, as compared with only 448 tons in the previous month. This brings the total imports for the first eleven months of 1957 to 10,809 tons, against 13,827 tons in the comparable period of 1956 and 14,778 tons in the first eleven months of 1955.

Arsenic.—Imports of arsenic trioxide into the U.K. during November totalled only 37 tons—a fall of 88 tons from the previous month's imports. Activity in this market was at its usual quiet level during December and no price alterations were recorded. Metal is still quoted at £400 a ton and trioxide £40 to £45 a ton.

Bismuth.—Bismuth is still quoted at 16s. a lb. and there were no unusual market movements during the month of December to record. November imports totalled 143,067 lb. and the total for the first eleven months of the year reached 861,374 lb.

Cobalt.—As was suggested in last month's report there was no alteration in the overall cobalt market situation during December with the price of metal in the U.K. remaining unchanged at 16s. per lb. Whether any price alterations will be seen in the next few months remains to be seen.

Cobalt imports during November totalled 357,829 lb., as compared with 1,120 lb. in the previous month—an unusually low figure.

Cadmium.—Following the rumours mentioned last month regarding the possibility of a fall in the price of cadmium sold in the U.K., on January 2 the price fell to 10s. per lb. for U.K. and Empire material. This fall followed the U.S. price decrease which occurred on December 24. Imported material is still quoted in the U.K. at 11s. 3d. a lb.

Imports of cadmium during November were 204,218 lb., bringing the total for the eleven months ending November 30 to over 2,000,000 lb.

Chromium.—Nothing interesting happened in the chromium metal market during December. The market continues its uneventful progress with prices unchanged.

Tantalum.—Compared with October imports those of November were up by a third to 12 tons, a figure which, as noted before, is indicative of the general condition of this market. Once again owing to the lack of business passing we are unable to quote a tantalite-columbite price, but tantalite as such is indicated at 900s. to 1,000s. per unit c.i.f.

Platinum.—A number of interesting events occurred in this market during December among them being the fall in price of U.K. and Empire refined metal to £27 10s. to £28 10s. per troy oz. This move came as no surprise to the market due to the low level of consumer interest which has characterized this market for some months past.

In the United States leading producers have cut their prices and are quoting $77 per troy oz. for bulk lots and $80 for smaller quantities. Both the reduction in the U.K. and that in the U.S.A. have been brought about by a number of factors; among these is the competition from material from the U.S.S.R. which has been appearing on the world market in increasing quantities for some time now. As a result of these price reductions it has been decided to cut back operations at Rustenburg by 40%.

Iridium.—Despite the fall in the price of platinum this member of the platinum group has shown no alteration in price and is still quotable at £27 to £30 per troy oz.

Osmium.—Osmium has showed no change since the last report and with only the usual amount of interest passing is still quoted at £22 to £25 nominal per troy oz.

Palladium.—Nothing emerged during December to change the palladium outlook; the price continues to be quoted at £7 10s. to £8 per troy oz.

Tellurium.—There were no changes to record in this market during December and only the usual amount of consumer interest was catered for. Prices did not move and are still quoted at 15s. to 16s. per lb.

Tungsten.—Following the steadiness of November tungsten ore quotations the feature of the December period was the decline to below 100s. a unit. The main factor causing the fall in prices was and still is the offers of material from Bolivia. Consumers' stocks in Europe are fairly low and it seems probable that a little more buying interest may be manifested in the not too distant future although whether in

the present state of the market this would be sufficient to harden prices remains to be seen. Following the spate of mine closures during the last two or three months, mine output generally seems to be at a fairly low level; 65% material is at present quoted at 92s. 6d. to 100s. per unit of WO_3.

Nickel.—Following the decline in open-market nickel prices in November this quotation has continued to drift downwards and is now quotable at £700 to £800 nominal. Material from Canada is still being quoted at £600 a ton. With open-market prices falling by fairly large sums at a time it may be only a matter of a few weeks before the open-market and fixed-price metal are sold at the same price. On the other hand, there may be some resistance to any further fall on the part of sellers.

U.K. imports of nickel in November totalled 19,926 cwt. bringing the total for the first eleven months to 165,596 cwt. In the report for November the figures given for October imports should have been in cwt. and not in tons.

Chrome Ore.—The expected decline in the price of Rhodesian chrome has now materialized and metallurgical grade 48% is quoted at £17 5s. a ton c.i.f. effective January 1, 1958. This decline, mainly due to the general market weakness and lack of consumer buying interest, was assisted by a reduction in Rhodesian freight rates.

With the present low rate of consumer interest there are rumours of a possibility of cutbacks in mine production in certain areas.

Molybdenum.—After more than five months the strike at the Langeloth plant of the Climax Molybdenum Co. ended early in December. With, as mentioned in the previous report, the U.S. Government contract for low-grade material ended, Climax will be able to devote more of its resources to normal production and coupling this with the anticipated new production from Anaconda's El Salvador mine in Chile there is every indication that an easier supply position will obtain in the immediate future.

The U.K. price remains at 8s. 5d. per lb. of metal contained.

Manganese.—The lack of interest on the part of manganese buyers was reflected during December in another price fall. This material is now quoted at 109d. to 117d. per unit of Mn, c.i.f. This fall has not, however, been paralleled in the Indian f.o.b. quotation. It is interesting to note that the majority of consuming countries are not entering into forward contracts for as much material as in previous years. This is due, in part, to the fact that following the high prices of 1956 the majority of consumers were overbought in relation to their 1957 requirements and therefore stocks are rather higher than needed.

Tin, Copper, Lead, and Zinc Markets

Tin, minimum 99·75%; Copper, electro; Lead, minimum 99·75%; and Zinc, minimum 98%, per ton.

Date	Tin		Copper		Lead		Zinc	
	Settlement	3 Months	Spot	3 Months	Spot	3 Months	Spot	3 Months
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Dec. 10	730 10	730 10	180 2½	184 12½	69 7½	71 2½	61 2½	61 12½
11	730 10	730 15	176 5	181 0	69 15	71 5	61 7½	61 12½
12	730 10	730 15	177 17½	181 17½	69 5	70 7½	61 2½	61 5
13	731 0	735 5	179 5	183 12½	70 17½	71 12½	61 17½	62 7½
16	732 10	741 5	188 15	193 5	72 7½	73 0	62 15	63 2½
17	730 10	735 10	183 2½	187 7½	72 5	73 3¾	62 13¾	62 13¾
18	730 10	732 15	180 12½	183 2½	72 3¾	72 17½	62 17½	62 17½
19	730 10	730 15	180 12½	185 5	73 12½	73 12½	63 2½	63 7½
20	730 10	731 0	180 17½	185 7½	74 5	74 7½	63 10	63 12½
23	730 10	731 5	178 10	183 2½	73 7½	73 8¾	62 8¾	62 11¼
24	730 10	732 5	179 12½	183 15	73 7½	73 7½	62 1¼	62 2½
25	—	—	—	—	—	—	—	—
26	—	—	—	—	—	—	—	—
27	730 10	731 15	180 2½	183 15	73 6¼	73 6¼	61 12½	61 12½
30	730 10	730 15	182 2½	185 12½	73 17½	73 12½	61 17½	61 17½
31	731 0	728 5	181 5	184 10	73 2½	73 7½	61 7½	61 12½
Jan. 1	—	—	—	—	—	—	—	—
2	730 10	728 5	180 0	183 5	72 2½	72 5	61 10	61 12½
3	730 10	728 5	178 7½	181 17½	71 7½	71 12½	61 2½	61 7½
6	730 10	727 15	179 7½	182 12½	71 15	72 2½	61 10	61 12½
7	730 10	730 10	178 18¾	182 12½	72 17½	73 2½	62 17½	62 17½
8	730 10	731 10	175 17½	178 17½	72 2½	72 7½	62 16¼	62 8¾
9	—	—	—	—	—	—	—	—

Statistics

TRANSVAAL AND O.F.S. GOLD OUTPUTS

	November		December	
	Treated Tons.	Yield Oz.†	Treated Tons.	Yield Oz.*
Blyvooruitzicht	102,000	61,176	95,000	57,160
Brakpan	127,000	18,554	131,000	18,942
Buffelsfontein‡	110,000	35,752	108,000	35,724
City Deep	149,000	28,300	139,000	27,201
Cons. Main Reef	140,000	21,828	130,000	21,240
Crown Mines	225,000	34,197	222,000	34,012
Daggafontein	221,000	47,081	220,000	46,861
Doornfontein‡	85,000	35,909	84,000	35,280
D'rb'n Roodeport Deep	181,000	32,565	179,000	32,087
East Champ D'Or‡	11,500	382	11,500	393
East Daggafontein	92,000	15,327	91,000	15,167
East Geduld	127,000	39,055	120,000	36,902
East Rand P.M.	218,000	56,390	214,000	54,985
Eastern Transvaal Consol	18,500	5,948	18,700	6,044
Ellaton‡	32,500	7,339	32,000	7,357
Freddies Consol.	50,000	17,945	49,000	16,907
Free State Geduld	64,000	45,149	62,500	44,374
Geduld	83,000	13,164	83,000	13,174
Government G.M. Areas‡	60,000	10,032	60,000	10,266
Grootvlei Proprietary	198,000	42,262	195,000	41,603
Harmony Gold Mining	81,000	32,404	72,000	29,531
Hartebeestfontein‡	85,000	44,625	86,000	47,300
Libanon	103,000	23,022	103,000	23,034
Loraine	61,000	11,935	62,000	12,058
Luipaards Vlei‡	122,000	14,360	120,000	14,213
Marievale Consolidated	72,000	18,906	69,000	18,213
Merriespruit‡	—	—	—	—
Modderfontein East	130,000	13,534	131,000	13,166
New Kleinfontein	93,000	11,737	90,000	11,377
New Klerksdorp‡	11,200	1,264	10,400	1,124
President Brand	68,500	51,900	68,000	51,504
President Steyn	92,000	35,162	91,000	34,745
Rand Leases	168,000	25,452	168,000	25,284
Randfontein‡	162,000	13,871	159,000	13,998
Rietfontein Consolid't'd.	23,500	5,557	24,000	5,678
Robinson Deep	75,000	15,900	74,000	14,695
Rose Deep	54,000	7,424	56,000	7,297
St. Helena Gold Mines	115,000	33,458	112,000	32,920
Simmer and Jack	95,500	17,994	93,500	17,702
S. African Land and Ex.	86,000	17,458	86,000	17,651
S. Roodepoort M.R.	29,000	6,872	28,000	6,838
Spaarwater Gold	10,700	3,270	19,700	3,278
Springs	127,000	14,326	127,000	14,232
Stilfontein Gold Mining‡	108,000	53,034	107,000	52,627
Sub Nigel	66,500	16,708	66,500	16,958
Transvaal G.M. Estates	15,200	3,045	—	—
Vaal Reefs‡	67,500	30,642	67,500	30,648
Van Dyk Consolidated	73,000	14,047	71,000	13,200
Venterspost Gold	120,000	29,028	120,000	29,208
Village Main Reef	33,500	5,607	31,000	4,532
Virginia O.F.S.‡	101,000	26,361	97,000	24,736
Vlakfontein	49,000	17,425	48,000	17,281
Vogelstruisbult‡	99,000	22,637	98,000	22,639
Welkom Gold Mining	81,000	24,138	79,000	23,921
West Driefontein‡	75,000	71,993	75,000	72,185
West Rand Consol. ‡	204,000	20,201	200,000	19,141
Western Holdings	99,000	50,428	95,000	49,404
Western Reefs	117,000	27,070	114,000	26,453
Witwatersrand Nigel	17,600	4,294	17,600	4,264

† 249s. 0d. * 250s. 2d. ‡ Gold and Uranium.

COST AND PROFIT IN THE UNION

	Tons milled	Yield per ton	Work'g cost per ton	Work'g profit per ton	Total working profit
		s. d.	s. d.	s. d.	£
Sept.,* 1956	17,390,400	57 8	42 10	14 10	19,104,984
Oct.	—	—	—	—	—
Nov.	—	—	—	—	—
Dec.	16,444,200	59 8	44 5	15 3	19,449,432
Jan., 1957	—	—	—	—	—
Feb.	—	—	—	—	—
Mar.	16,430,800	60 8	44 8	16 0	20,657,462
April	—	—	—	—	—
May	—	—	—	—	—
June*	16,785,200	62 4	45 1	17 3	22,595,371
July	—	—	—	—	—
August	—	—	—	—	—
Sept.*	16,699,900	64 0	45 6	17 3	24,193,575

* 3 Months.

PRODUCTION OF GOLD IN SOUTH AFRICA

	Rand and O.F.S.	Outside	Total
	Oz.	Oz.	Oz.
December, 1956	1,309,435	36,707	1,315,778
January, 1957	1,279,071	39,221	1,380,351
February	1,341,130	29,912	1,318,052
March	1,288,140	38,765	1,405,422
April	1,366,657	36,979	1,398,667
May	1,361,688	45,361	1,450,668
June	1,405,307	24,957	1,420,021
July	1,395,064	53,099	1,479,439
August	1,426,340	38,941	1,459,794
September	1,400,745	37,611	1,438,356
October	1,416,211	39,996	1,456,207
November	1,386,047	36,470	1,422,517

NATIVES EMPLOYED IN THE SOUTH AFRICAN MINES

	Gold Mines	Coal Mines	Total
March 31, 1957	342,840	30,156	367,031
April 30	343,240	30,154	372,996
May 31	341,199	29,906	373,394
June 30	335,756	29,411	371,105
July 31	329,142	29,083	365,167
August 31	322,847	28,604	351,451
September 30	315,955	28,170	344,125
October 31	310,428	28,020	338,448
November 30	305,104	27,619	332,723

MISCELLANEOUS METAL OUTPUTS

	4-Week Period To Dec. 15		
	Tons Ore	Lead Concs. tons	Zinc Concs. tons
Broken Hill South	28,400	4,334	5,781
Electrolytic Zinc	17,158	896	5,029
Lake George	17,500	1,280	2,454
Mount Isa Mines**	63,538	3,765†	2,676
New Broken Hill	—	—	—
North Broken Hill	32,408	6,025	6,264
Zinc Corp.	—	—	—
Rhodesia Broken Hill*	—	—	—

* 3 Mths. ** Copper 1,985 tons. † Metal.

RHODESIAN GOLD OUTPUTS

	November		December	
	Tons	Oz.	Tons	Oz.
Cam and Motor	30,686	9,598	31,044	9,525
Falcon Mines	18,745	3,899	19,230	3,402
Globe and Phœnix	6,000	5,899	—	—
Motapa Gold Mining	12,700	1,809	—	—
Mazoe	2,819	904	2,991	898
Coronation Syndicate	11,128	4,153	11,340	4,033

WEST AFRICAN GOLD OUTPUTS

	November		December	
	Tons	Oz.	Tons	Oz.
Amalgamated Banket	64,053	13,652	61,201	13,926
Ariston Gold Mines	40,500	12,826	42,000	12,904
Ashanti Goldfields	28,000	22,500	28,000	22,500
Bibiani	33,500	6,900	33,500	6,900
Bremang	—	4,625	—	4,711
Ghana Main Reef	11,563	4,129	—	—
Konongo	5,060	3,870	5,130	3,925
Lyndhurst	—	—	—	—
Marlu	—	—	—	—
Nanwa	—	—	—	—
Taquah and Abosso	—	—	—	—

PRODUCTION OF GOLD AND SILVER IN RHODESIA

	1956		1957	
	Gold (oz.)	Silver (oz.)	Gold (oz.)	Silver (oz.)
January	44,619	5,841	44,337	6,134
February	41,858	5,347	41,607	5,697
March	43,799	5,543	43,831	8,179
April	46,577	6,346	46,754	6,854
May	45,822	7,891	42,650	5,606
June	45,996	6,838	46,682	6,441
July	46,178	7,084	41,922	5,781
August	46,427	6,531	44,001	5,897
September	44,654	6,400	45,762	5,677
October	44,486	6,473	—	—
November	42,648	6,599	—	—
December	43,327	6,008	—	—

WESTRALIAN GOLD PRODUCTION

	1955	1956	1957
	Oz.	Oz.	Oz.
January	65,711	66,388	106,722
February	63,441	94,638	64,949
March	111,675	66,944	67,121
April	62,211	60,415	66,435
May	61,672	62,294	64,886
June	64,201	63,570	65,142
July	63,441	69,883	74,420
August	70,221	72,303	75,727
September	75,055	62,204	64,422
October	71,102	64,594	64,524
November	66,622	64,113	—
December	66,679	65,031	—
Total	842,004	812,377	—

AUSTRALIAN GOLD OUTPUTS

	4-Week Period			
	To Nov. 26		To Dec. 24	
	Tons	Oz.	Tons	Oz.
Boulder Perseverance	—	—	—	—
Central Norseman	13,371	7,302	14,093	7,818
Crœsus Proprietary	—	—	—	—
Gold Mines of Kalgoorlie	40,926	10,293	41,595	11,452
Golden Horse Shoe*	—	—	—	—
Gt. Boulder Prop.*	120,551	29,243	—	—
Gt. Western Consolidated	42,161	6,581	39,408	6,717
Kalgoorlie Enterprise	—	—	—	—
Kalgurli Ore Treatment	—	—	—	—
Lake View and Star*	—	—	—	—
Moonlight Wiluna*	—	—	—	—
Morning Star (G.M.A.)	—	—	—	—
Mount Ida	—	—	—	—
New Coolgardie	—	—	—	—
North Kalgurli	25,525	6,086	—	—
Sons of Gwalia	12,514	2,340	—	—
South Kalgurli	—	—	—	—
Mount Morgan	—	4,070	—	4,171

* 3 Months.

ONTARIO GOLD AND SILVER OUTPUT

	Tons Milled	Gold Oz.	Silver Oz.	Value Canad'n $
July, 1956	711,076	191,009	31,212	6,586,430
Aug.	676,402	182,147	30,140	6,290,128
September	701,236	192,979	26,355	6,627,079
October	754,191	212,490	34,854	7,159,732
November	747,059	209,797	34,135	7,102,110
December	741,525	213,846	60,129	7,180,865
Jan., 1957	759,681	210,404	33,082	7,114,391
February	702,636	197,225	32,199	6,635,527
March	793,674	215,830	35,787	7,250,018
April	771,608	216,457	35,685	7,314,450
May	790,159	222,436	37,241	7,509,638
June	738,384	207,897	32,544	6,945,127
July	718,468	198,620	30,620	6,572,323
August	701,174	192,453	31,647	6,410,429
September	722,384	205,471	34,248	6,947,813
October	772,383	224,217	37,086	7,657,426

MISCELLANEOUS GOLD AND SILVER OUTPUTS

	Nov.		Dec.	
	Tons	Oz.	Tons	Oz.
British Guiana Cons.	—	808	—	—
Central Victoria Dredging	—	—	—	—
Clutha River	—	634	—	251
Emperor Mines (Fiji)*	38,433	14,682	—	—
Frontino Gold (Colombia)	—	—	—	—
Geita Gold (Tanganyika)	25,000	3,527	—	—
Harrietville (Aust.)	—	—	—	—
Lampa (Peru)†	—	36,284	—	39,560
Loloma (Fiji)*	6,225	2,909	—	—
New Guinea Goldfields	—	—	—	—
St. John d'el Rey (Brazil)	21,300	£105,600	—	—
Yukon Consol.	—	$183,000	—	—

* 3 Months. † Ozs. Silver : 62 tons copper; 66½ tons.

OUTPUTS OF MALAYAN TIN COMPANIES IN LONG TONS OF CONCENTRATES

	Oct.	Nov.	Dec.
Ampat Tin	100	92½	—
Austral Amalgamated	194	—	—
Ayer Hitam	—	55	—
Batu Selangor	—	—	—
Berjuntai	130	144	—
Chenderiang	—	15½	—
Gopeng Consolidated	—	—	243*
Hongkong Tin	—	47	—
Idris Hydraulic	—	13	—
Ipoh	31½	36	22
Jelapang Tin	—	—	—
Kampong Lanjut	51	102	—
Kamunting	143	134	—
Kent (F.M.S.)	—	—	—
Kepong	—	33	155*
Killinghall	—	70	—
Kinta Kellas	49½	45	36
Kinta Tin Mines	54	68	57
Klang River	—	—	—
Kramat	30	50½	—
Kuala Kampar	66½	75	—
Kuala Lumpur	—	—	—
Kuchai	—	—	—
Lahat Mines	—	—	—
Larut	21	24½	—
Lower Perak	213	155½	—
Malayan	—	212	—
Malaysiam	10	10	—
Pacific Tin Consolidated	—	—	—
Pahang Consolidated	180	200	184
Pengkalen	—	—	116*
Petaling Tin	—	—	217*
Puket	—	48	—
Rahman Hydraulic	27½	—	—
Rambutan	—	—	58
Rantau	84	67	—
Rawang Concessions	—	—	—
Rawang Tin Fields	—	—	—
Renong	49	60	—
Selayang	—	—	—
Siamese Tin Syndicate (Malaya)	29½	23	36
Southern Kinta	330½	305	—
Southern Malayan	—	321	—
Southern Tronoh	—	43	—
Sungei Besi	—	159	—
Sungei Kinta	14	17	20½
Sungei Way	—	124½	—
Taiping Consolidated	58½	72	—
Tambah	—	—	—
Tanjong	50	58½	59
Tekka	—	—	49
Tekka-Taiping	31	30	—
Temoh	—	—	—
Tongkah Compound	—	—	—
Tongkah Harbour	85½	78	—
Tronoh	—	227½	—
Ulu Klang	—	—	—

* 3 Months.

MISCELLANEOUS TIN COMPANIES' OUTPUTS IN LONG TONS OF CONCENTRATES

	Nov.		Dec.	
	Tin	Columbite	Tin	Columbite
Amalgamated Tin Mines	434	49	—	—
Anglo-Burma Tin	18	—	19	—
Bangrin	59	—	60	—
Beralt	40	144†	39	149†
Bisichi	96	12½	79½	10½
Ex-Lands Nigeria	90	—	48	—
Geevor	57	—	55	—
Gold and Base Metal	136	16	52	7
Jantar Nigeria	30	20	23	15
Jos Tin	18½	—	—	—
Kaduna Prospectors	4	—	7	—
Kaduna Syndicate	25	—	38	—
Katu Tin	42	—	67	—
Kefi Tin	19	25	—	—
London Nigerian Mines	15	—	—	—
Naraguta Extended	18½	—	17	—
Naraguta Karama	12	—	10½	—
Naraguta Tin	—	—	—	—
Renong Consolidated	35	—	40½	—
Ribon Valley (Nigeria)	19	—	24	—
Siamese Tin Syndicate	111	—	82½	—
South Bukeru	—	—	—	—
South Crofty	60½	—	56½	—
Thabawleik	—	—	—	—
Tin and Ass. Minerals	—	—	—	—
Tin Fields of Nigeria	3	—	6	—
United Tin Areas of Nigeria	5	1	4½	½

† Wolfram.

SOUTH AFRICAN MINERAL OUTPUT

September, 1957

Gold	1,437,775 oz.
Silver	151,137 oz.
Diamonds	202,551 carats.*
Coal	3,163,375 tons.
Copper	(a) 240 tons in matte and copper-gold concentrates. (b) 3,885 tons of 99·46%.
Tin	250 tons concs.
Platinum (concentrates, etc.)	—
Platinum (crude)	—
Asbestos	12,113 tons.
Chrome Ore	67,962 tons.
Manganese Ore	76,130 tons.
Lead Concs.	— tons.

* Aug., 1957.

IMPORTS OF ORES, METALS, ETC., INTO UNITED KINGDOM

		Oct.	Nov.
Iron Ore	tons	1,694,033	1,392,406
Manganese Ore	,,	33,893	52,672
Iron and Steel	,,	112,696	102,283
Iron Pyrites	,,	38,212	32,928
Copper Metal	,,	35,151	31,977
Tin Ore	,,	6,343	8,302
Tin Metal	,,	751	4,082
Lead	,,	16,433	11,778
Zinc Ore and Conc.	,,	19,005	23,161
Zinc	,,	13,571	10,596
Tungsten Ores	,,	478	535
Chrome Ore	,,	12,182	15,386
Bauxite	,,	13,370	26,140
Antimony Ore and Concs.	,,	448	1,182
Titanium Ore	,,	21,805	32,149
Nickel Ore	,,	2,625	3,900
Tantalite/Columbite	,,	9	12
Sulphur	,,	17,840	24,751
Barytes	,,	5,655	3,430
Asbestos	,,	12,349	15,308
Magnesite	,,	4,779	5,368
Mica	,,	254	449
Graphite	,,	218	686
Mineral Phosphates	,,	72,495	64,608
Molybdenum Ore	,,	328	622
Nickel	cwt.	16,390	27,676
Aluminium	,,	259,577	515,793
Mercury	lb.	73,175	71,519
Bismuth	,,	34,650	143,067
Cadmium	,,	181,906	204,218
Cobalt and Cobalt Alloys	,,	1,170	357,829
Selenium	,,	12,477	4,459
Petroleum Motor Spirit	1,000 gals.	52,422	58,957
,, Crude	,,	624,216	651,407

Prices of Chemicals

The figures given below represent the latest available.

		£	s.	d.
Acetic Acid, Glacial	per ton	98	0	0
,, ,, 80% Technical	,,	92	0	0
Alum, Comml.	,,	25	0	0
Aluminium Sulphate	,,	16	10	0
Ammonia, Anhydrous	per lb.		2	0
Ammonium Carbonate	per ton	59	0	0
,, Chloride, 98%	,,	26	0	0
,, Phosphate (Mono- and Di-)	,,	102	0	0
Antimony Sulphide, golden	per lb.		3	0
Arsenic, White, 99/100%	per ton	47	10	0
Barium Carbonate (native), 94%	,,	Nominal		
,, Chloride	,,	53	0	0
Barytes (Bleached)	,,	20	0	0
Benzole	per gal.		5	2
Bleaching Powder, 36% Cl.	per ton	30	7	6
Borax	,,	44	0	0
Boric Acid, Comml.	,,	73	10	0
Calcium Carbide	,,	40	17	9
,, Chloride, solid, 70/75%	,,	12	10	0
Carbolic Acid, crude 60's	per gal.		8	3
Carbon Bisulphide	per ton	62	10	0
Chromic Acid (ton lots)	per lb.		2	2¼
Citric Acid	per cwt.	10	15	0
Copper Sulphate	per ton	71	0	0
Creosote Oil (f.o.r. in Bulk)	per gal.		1	1
Cresylic Acid, 97–98%	,,		6	6
Hydrochloric Acid 28° Tw.	per carboy		13	0
Hydrofluoric Acid, 59/60%	per lb.		1	1
Iron Sulphate	per ton	3	17	6
Lead, Acetate, white	,,	124	0	0
,, Nitrate	,,	116	0	0
,, Oxide, Litharge	,,	110	10	0
,, Red	,,	108	10	0
,, White	,,	118	10	0
Lime, Acetate, brown	,,	40	0	0
Magnesite, Calcined	,,	20	0	0
,, Raw	,,	9	0	0
Magnesium Chloride, ex W'h'se	,,	16	0	0
,, Sulphate, Comml.	,,	15	10	0
Methylated Spirit, Industrial, 66 O.P.	per gal.		6	3
Nitric Acid, 80° Tw.	per ton	37	10	0
Oxalic Acid	,,	129	0	0
Phosphoric Acid (S.G. 1·750)	per lb.		1	4
Pine Oil	per ton	Nominal		
Potassium Bichromate	per lb.		1	2½
,, Carbonate (hydrated)	per ton	74	10	0
,, Chloride, 96%	,,	21	0	0
,, Iodide	per lb.		9	0
,, Amyl Xanthate	,,	Nominal		
,, Ethyl Xanthate	,,	Nominal		
,, Hydrate (Caustic) solid	per ton	118	0	0
,, Nitrate	per cwt.	4	1	0
,, Permanganate	per ton	193	10	0
,, Sulphate, 48%	,,	22	6	0
Sodium Acetate	,,	99	0	0
,, Arsenate, 58–60%	,,	Nominal		
,, Bicarbonate	,,	15	0	0
,, Bichromate	per lb.		1	0
,, Carbonate (crystals)	per ton	Nominal		
,, ,, (Soda Ash) 58%	,,	13	10	0
,, Chlorate	,,	87	0	0
,, Cyanide 100% NcAN basis	per cwt.	6	6	6
,, Hydrate, 76/77%, solid	per ton	33	0	0
,, Hyposulphite, Comml.	,,	32	15	0
,, Nitrate, Comml.	,,	9	10	0
,, Phosphate (Dibasic)	,,	40	10	0
,, Prussiate	per lb.		1	0¼
,, Silicate	per ton	11	0	0
,, Sulphate (Glauber's Salt)	,,	9	15	0
,, ,, (Salt-Cake)	,,	8	0	0
,, Sulphide, flakes, 60/62%	,,	35	12	6
,, Sulphite, Comml.	,,	27	0	0
Sulphur, American, Rock (Truckload)	,,	17	0	0
,, Ground, Crude	,,	19	0	0
Sulphuric Acid, 168° Tw.	,,	10	15	0
,, ,, free from Arsenic, 140° Tw.	,,	8	3	0
Superphosphate of Lime, 18% P_2O_5	,,	14	16	0
Tin Oxide	,,	Nominal		
Titanium Oxide, Rutile	,,	177	0	0
,, White, 25%	,,	83	10	0
Zinc Chloride	,,	Nominal		
,, Dust, 95/97% (4-ton lots)	,,	107	0	0
,, Oxide	,,	88	0	0
,, Sulphate	,,	32	0	0

Share Quotations

Shares of £1 par value except where otherwise stated.

GOLD AND SILVER:	Dec. 11, 1957 £ s. d.	Jan. 6, 1958 £ s. d.
SOUTH AFRICA:		
Blinkpoort (5s.)	1 19 3	2 0 9
Blyvooruitzicht (2s. 6d.)	1 0 0	19 3
Brakpan (5s.)	4 3	4 3
Buffelsfontein (10s.)	1 19 3	1 19 9
City Deep	13 0	12 9
Consolidated Main Reef	12 9	12 3
Crown Mines (10s.)	1 4 0	1 2 6
Daggafontein (5s.)	1 6 3	1 5 0
Dominion Reefs (Ord. 5s.)	14 9	13 6
Doornfontein (10s.)	1 2 0	1 2 6
Durban Roodepoort Deep (10s.)	1 6 9	1 5 3
East Champ d'Or (2s. 6d.)	2 3	2 3
East Daggafontein (10s.)	8 3	7 9
East Geduld (4s.)	1 1 0	1 0 0
East Rand Proprietary (10s.)	2 0 6	1 19 0
Freddies Consol.	3 9	3 9
Free State Dev. (5s.)	4 9	5 0
Free State Geduld (5s.)	4 0 0	4 2 0
Free State Saaiplaas (10s.)	17 0	16 6
Geduld	3 3 0	2 16 0
Government Gold Mining Areas (5s.)	3 3	3 6
Grootvlei (5s.)	15 6	15 0
Harmony (5s.)	1 13 3	1 12 9
Hartebeestfontein (10s.)	3 1 3	2 19 6
Libanon (10s.)	7 0	6 6
Loraine (10s.)	3 9	3 3
Luipaards Vlei (2s.)	10 3	9 9
Marievale (10s.)	18 6	17 3
Merriespruit (5s.)	3 9	3 9
Modderfontein B (3d.)	2 3	2 3
Modderfontein East	12 0	11 6
New Kleinfontein	3 9	3 9
New Pioneer (5s.)	1 7 6	1 7 3
New State Areas (16s.)	1 3	1 3
President Brand (5s.)	2 8 0	2 10 3
President Steyn (5s.)	1 6 9	1 8 0
Rand Leases (10s.)	3 9	3 9
Randfontein	1 7 6	1 4 0
Riebeeck (10s.)	12 3	12 9
Rietfontein (5s.)	8 9	8 0
Robinson Deep (7s. 6d.)	7 3	6 9
Rose Deep (9s. 6d.)	9 6	9 6
St. Helena (10s.)	1 15 9	1 17 3
Simmer and Jack (2s. 6d.)	4 0	3 9
South African Land (3s. 6d.)	19 6	18 9
Springs (5s.)	2 0	1 9
Stilfontein (5s.)	1 19 3	1 16 9
Sub Nigel (10s.)	14 3	12 3
Vaal Reefs (5s.)	2 0 9	2 0 0
Van Dyk (9s.)	3 6	3 6
Venterspost (10s.)	12 6	12 6
Virginia (5s.)	8 0	7 9
Vlakfontein (10s.)	14 9	14 6
Vogelstruisbult (10s.)	10 3	9 9
Welkom (5s.)	14 3	15 0
West Driefontein (10s.)	4 15 0	4 14 3
West Rand Consolidated (10s.)	1 6 6	1 5 0
West Witwatersrand Areas (2s. 6d.)	1 16 3	1 16 0
Western Holdings (5s.)	4 6 0	4 9 3
Western Reefs (5s.)	1 6 3	1 4 9
Winkelhaak (10s.)	17 6	17 3
Witwatersrand Nigel (2s. 6d.)	1 4	1 3
RHODESIA:		
Cam and Motor (2s. 6d.)	8 0	7 9
Chicago-Gaika (10s.)	16 3	13 9
Coronation (2s. 6d.)	4 0	3 9
Falcon (5s.)	7 0	7 0
Globe and Phœnix (5s.)	1 5 6	1 6 0
Motapa (5s.)	9	9
GOLD COAST:		
Amalgamated Banket (3s.)	1 0	10
Ariston Gold (2s. 6d.)	4 0	3 9
Ashanti Goldfields (4s.)	14 0	13 6
Bibiani (4s.)	2 3	2 3
Bremang Gold Dredging (5s)	1 3	1 3
Ghana Main Reef (5s.)	1 6	1 3
Konongo (2s.)	1 6	1 6
Kwahu (2s.)	2 3	2 3
Taquah and Abosso (3s.)	6	9
Western Selection (5s.)	4 6	4 9
AUSTRALASIA:		
Gold Fields Aust. Dev. (3s.), W.A.	2 0	2 0
Gold Mines of Kalgoorlie (10s.)	11 0	10 9
Great Boulder Propriet'y (2s.), W.A.	12 3	12 0
Lake View and Star (4s.), W.A.	19 6	1 0 0
London-Australian (2s.)	9	9
Mount Morgan (10s.), Q.	9 0	8 9
New Guinea Gold (4s. 3d.)	1 9	1 6
North Kalgurli (1912) (2s.), W.A.	6 9	7 0
Sons of Gwalia (10s.), W.A.	2 9	2 6
Western Mining (5s.), W.A.	8 9	8 9

	Dec. 10, 1957 £ s d.	Jan. 6, 1958 £ s. d.
MISCELLANEOUS:		
Fresnillo ($1·00)	2 2 6	2 1 6
Kentan Gold Areas (1s.), E. Africa	3	4
St. John d'el Rey, Brazil	2 0 0	2 6 3
Yukon Consolidated ($1)	4 3	4 0
COPPER:		
Bancroft Mines (5s.), N. Rhodesia	17 9	15 9
Esperanza (2s. 6d.), Cyprus	1 3	1 3
Indian (2s.)	3 3	2 9
Magundi (5s.)	3 0	4 0
Messina (5s.), Transvaal	4 7 6	3 16 3
Mount Lyell, Tasmania	17 3	17 0
Nchanga Consolidated, N. Rhodesia	8 15 0	8 17 0
Rhokana Corporation, N. Rhodesia	24 15 0	25 0 0
Roan Antelope (5s.), N. Rhodesia	7 9	7 9
Tanganyika Concessions (10s.)	5 16 3	5 10 0
LEAD-ZINC:		
Broken Hill South (5s.), N.S.W.	3 2 9	3 0 0
Burma Mines (3s. 6d.)	2 3	2 0
Consol. Zinc Corp. Ord.	2 10 0	2 9 6
Electrolytic Zinc, Tasmania (Pref. 5s.)	2 12 6	2 12 6
Lake George (5s.), N.S.W.	4 9	4 0
Mount Isa, Queensland (5s. Aust.)	1 3 0	1 2 6
New Broken Hill (5s.), N.S.W.	1 14 9	1 14 9
North Broken Hill (5s.), N.S.W	4 3 9	3 18 9
Rhodesia Broken Hill (5s)	8 3	8 0
San Francisco (10s.), Mexico	19 6	19 9
TIN:		
Amalgamated Tin (5s.), Nigeria	6 6	5 9
Ampat (4s.), Malaya	7 3	7 6
Ayer Hitam (5s.), Malaya	1 5 0	1 4 6
Beralt (5s.), Portugal	1 10 3	1 5 9
Bisichi (2s. 6d.), Nigeria	3 9	3 6
Ex-Lands (2s.), Nigeria	2 0	2 0
Geevor (5s.), Cornwall	17 9	15 3
Gold Base Metals (2s. 6d.), Nigeria	1 0	1 0
Hongkong (5s.), Malaya	6 9	6 0
Jantar Nigeria (3s.)	2 6	2 6
Kaduna Syndicate (2s.), Nigeria	2 3	2 3
Kamunting (5s.), Malaya	9 0	8 3
Kramat Pulai (3d.), Malaya	4 0	3 9
Malayan Tin Dredging (5s.)	11 9	11 3
Mawchi Mines (4s.), Burma	2 6	2 6
Naraguta Karama (5s.), Nigeria	—	9
Pahang (5s.), Malaya	5 6	4 9
Siamese Synd. (5s.)	8 9	8 6
South Crofty (5s.), Cornwall	6 6	6 6
Southern Kinta (5s.), Malaya	16 3	15 9
Southern Malayan (5s.)	9 3	9 0
Southern Tronoh (5s.), Malaya	8 6	8 6
Sungei Besi (4s.), Malaya	13 6	13 0
Sungei Kinta, Malaya	15 6	16 0
Tronoh (5s.), Malaya	11 6	9 9
United Tin Areas (2s. 6d.), Nigeria	5	4½
DIAMONDS:		
Anglo American Investment	8 5 0	7 13 0
Consol African Selection Trust (5s.)	1 3 3	11 0
Consolidated of S.W.A. Pref (10s.)	10 6	10 3
De Beers Deferred (5s.)	4 6 0	4 0 9
FINANCE, Etc.		
African & European (10s.)	3 0 9	3 0 0
Anglo American Corporation (10s.)	6 4 0	6 4 3
Anglo-French Exploration	1 3 0	1 2 9
Anglo Transvaal 'A' (5s.)	1 9 6	1 10 0
British South Africa (15s.)	2 11 9	2 11 3
British Tin Investment (10s.)	17 6	16 9
Broken Hill Proprietary	1 16 9	1 17 0
Camp Bird (10s.)	—	9 2
Central Mining	2 17 9	2 17 6
Central Provinces Manganese (10s.)	1 4 9	1 3 9
Consolidated Gold Fields	2 12 3	2 11 9
Consolidated Mines Selection (10s.)	1 12 3	1 14 3
East Rand Consolidated (5s.)	1 3	1 6
Free State Development (5s.)	4 9	5 0
General Exploration O.F.S. (2s. 6d.)	2 9	3 0
General Mining and Finance	3 15 0	3 16 3
H.E. Proprietary (5s.)	8 0	8 0
Johannesburg Consolidated	2 10 9	2 7 6
London & Rhod. M. & L. (5s.)	7 6	7 0
London Tin Corporation (4s.)	7 3	7 3
Lydenburg Est. (5s.)	13 6	13 0
Marsman Investments (10s.)	2 6	2 6
National Mining	1 0	1 0
Rand Mines (5s.)	3 6 9	3 11 0
Rand Selection (5s.)	1 13 6	1 14 3
Rhodesian Anglo American (10s.)	3 5 0	3 6 3
Rhodesian Corporation (5s.)	4 6	4 3
Rhodesian Selection Trust (5s.)	14 6	14 6
Rio Tinto (10s.)	2 15 0	2 12 0
Selection Trust (10s.)	3 6 0	3 7 0
South West Africa Co. (3s. 4d.)	16 3	16 3
Union Corporation (2s. 6d.)	2 1 3	2 0 6
West Rand Inv. Trust (10s.)	2 0 9	2 2 9
Zambesia Exploring	2 5 0	2 4 6

THE MINING DIGEST

A RECORD OF PROGRESS IN MINING, METALLURGY, AND GEOLOGY

In this section abstracts of important articles and papers appearing in technical journals and proceedings of societies are given, together with brief records of other articles and papers; also notices of new books and pamphlets and lists of patents on mining and metallurgical subjects.

Australia and Aluminium

The following notes relating to the aluminium prospects for Australia are abstracted from an article entitled "Background of Aluminium" which appeared in the November issue of *The Australian Mineral Industry Quarterly Review.* The author, Dr. J. A. Dunn, points out that in recent years the exploration of deposits of bauxite, first on Marchinbar Island and on Gove Peninsula in the Northern Territory and in 1956 around Weipa, on the western side of Cape York Peninsula, has caused a considerable amount of interest in the bauxite possibilities of this northern region of Australia. In the Northern Territory, in areas other than Marchinbar Island and Gove Peninsula, Rio Tinto Australian Exploration Pty., Ltd., have a permit to prospect bauxite deposits at several points along the northern coast of Arnhem Land, Reynolds Pacific Mines Pty., Ltd. (a subsidiary of the American company, Reynolds Metal Co.), have a permit to prospect a wide belt inland from the northern coast and Aluminium Laboratories, Ltd. (of Canada), have a permit to prospect a belt along the western coast of the Gulf of Carpentaria. Both Commonwealth Aluminium Corporation and Aluminium Laboratories, Ltd., are prospecting deposits on Cape York Peninsula. This activity has naturally led to thoughts on the eventual development of this region.

If the bauxite deposits in the Australian north are to be developed commensurately with their size, says Dr. Dunn, their products, whether they be bauxite, alumina, or aluminium, must enter into international trade. Apart from the many technical problems to be faced (perhaps the greatest of which is a suitable economic power supply if aluminium is to be produced eventually) in projects of this nature the marketing possibilities are the main deciding factor. It is not, however, the market position of to-day that is of importance in such long-term projects, the author says, their success being dependent on the accurate appraisal of the market position in the future, the timing of commencement of operation, and the competitive position of the projects within the estimated extended field of future world producers.

Many estimates of future aluminium consumption have been made, Dr. Dunn points out. Amongst the more authoritative the "Paley Report" of 1952 projected the possible increase in "Free World" demand for aluminium by 1970 to 6,000,000 tons, an average rate of increase of roughly 240,000 tons per year. Mr. Felix Wormser, formerly Assistant Secretary of the U.S. Department of the Interior, recently estimated that by 1975 aluminium usage will be two to three times the present level; this estimate is equal to a rate of increase between the limits 145,000 tons and 290,000 tons annually.

The years 1950–55 covered a period of general high-level industrial activity and expansion. During this period other metals were not in over-ample supply and prices of them were high for considerable periods; aluminium thus had a favourable field for competition, in addition to its widening scope in many new usages for which its particular properties are eminently suitable. As the back-log of demand became satisfied increased usage fell behind increased production; this difference will be adjusted in 1957 not only by reducing production below capacity but also by absorption of a certain amount of aluminium in the U.S. stockpile. With zinc and copper now back to and below more normal prices aluminium will meet with stronger competition for certain purposes. Also, secondary aluminium, now about 600,000 tons annually in the Free World, may be expected to increase greatly in the future. Thus, despite the vigorous usage research and marketing programmes of the leading aluminium producers a rate of increase in Free World real consumption of primary aluminium well below 240,000 tons must be postulated. Mr. Wormser's lower limit of 145,000 tons would seem to be more probable than his upper limit, but, having in mind that the appearance of a surplus in 1957 is to some extent related to a period of rather slackened industrial activity, a rather higher average rate of increase may be justified—of the order of 200,000 tons a year.

Such figures would be greatly increased should aluminium replace another metal in some very large-scale usage—for example, if aluminium were to take the place of steel for motor-car engine blocks as has

Table 1

World Aluminium Production Capacity ('000 long tons)

	1957.	*1965.* Decided projected capacity.	*1965.* Possible capacity, incl. projects under investigation.
United States	2,011 (*a*)	2,367	2,458
Canada	720	1,000	1,080
S. America	12	12	50
Europe	693	830	950
Africa	10	100	100–200 +
Asia	88	170	185
Australia	13	13	13
Free World Total	3,500 (*a*)	4,500	4,800–5,000
Soviet Sphere	700	1,250	1,250
World Total	4,200 (*a*)	5,750	6,000–6,250

(*a*) Includes U.S. new capacity early 1958.

Table 2

World Bauxite Recorded Reserves (millions tons)

U.S.A.	40
Jamaica	500
Haiti and Dominican Rep.	23
British Guiana	65
French Guiana	42
Surinam	50
Brazil	192
France	60
Italy	10
Greece	60–300
Turkey	45
Yugoslavia	105
Ghana	230
French West Africa	300
Nyasaland	60
India	250
Malaya	10
Indonesia	25
Australia	Large
U.S.S.R.	?
Hungary	250
Rumania	20
China	Several hundred
Others	20
World Total	2,500 *plus*

been envisaged. However, using these approximate limits, the Free World consumption may be estimated at 4–4½ million in 1965 and 4¾–5½ million in 1970.

Available data of world bauxite reserves are compiled in Table 2. It will be noted that the bulk of the reserves is in the tropical belt, as may be expected from their mode of origin ; Australia is the last of the extensive regions within this belt in which bauxite has been found. Some 25% of the reserves listed are located in the neighbourhood of the Caribbean.

Although material in the Australian Northern Territory deposits has the typical physical characteristics of most bauxite, the material *in situ* in the deposits of western Cape York Peninsula, Queensland, is physically different from that of the more important deposits of other countries. Within a flat coastal region of more than 2,000 sq. miles, at an elevation of up to 70 ft. above sea-level, widespread zones are covered to an average depth of perhaps 8 ft. by a loose pisolitic laterite gravel (as it is best described) consisting of close-packed pisolites with a small amount of interstitial fine ferruginous sand. With decrease in silica and increase in alumina content of the pisolites areas of this material grade to a loose pisolitic bauxite gravel, each " pebble " being a separate pisolite of bauxite. The reserves of bauxitic material which, after washing, would be acceptable to present-day alumina plants are not finally determined ; in addition, material not acceptable to-day may, as in the case of many other ores, be acceptable in the years ahead.

The early development of the bauxite deposits in Queensland and Northern Territory will be by the production of alumina. To what extent is it likely that Australian alumina production can find a place in world alumina trade up to the time when aluminium reduction on a large scale can also be developed in Australia ? It may be taken that countries within the Soviet sphere have adequate indigenous bauxite and other alumina-bearing resources. If it is assumed that the projected capacity in 1965 in Free World countries, listed in Table 1, will be fully utilized, then alumina requirements will be roughly as shown in Table 3.

Table 3

Free World Alumina Requirements for Aluminium Reduction (long tons)

	1956.	*1965* *Based on capacity.*
U.S.A.	3,000,000	4,800,000–4.900,000
Canada	1,100,000	2,000,000–2,160,000
South America	22,000	24,000– 100,000
Europe	1,300,000	1,600,000–1,900,000
Africa	—	200,000– 400,000 +
Asia	160,000	320,000
Australia	18,000	28,000

After a review of developments likely in other spheres Dr. Dunn suggests that, by the time large-scale alumina production can commence in Australia at some date in the early 1960's, there will be a large market for alumina in North America from oversea sources. With alumina available in Australia on the western side of the Pacific it may well prove that a re-alignment of the alumina trade in North America may take place. For the present, alumina from Jamaica supplies the Kitimat aluminium plant and alumina plants in the U.S. southern States supply reduction plants in Washington and Oregon ; a market is also available in this region for some alumina from Japan. Australian alumina may eventually find its more natural market on the western coast of America.

Turning to the metal prospects in Australia, the author says, it may be expected that some years will elapse before the many problems associated with the establishment of a large-scale aluminium reduction industry are solved and Australian aluminium is able to enter competitively into world markets. The capital cost per ton of plant capacity for such production is far greater than for other base metals. A determining factor in future plans will be power sources. It has been estimated that of the net mill cost of primary aluminium in the United States 30–40% is represented by the cost of bauxite and various transportation costs. It would seem, therefore, that where all operations through to metal reduction can be centred at the mine the saving in transportation may go far in compensating higher power costs. But, in the case of thermal power from coal, as coal would need to be transported to an alumina plant at the mine, back-loading of alumina may well permit a reduction plant on a coastal coal basin. Considerations such as these will determine the location of reduction plants by the various Australian companies which may eventually proceed to this stage.

To date the unrestricted availability of large amounts of power has determined the location of aluminium reduction works (power requirements for reduction and general plant purposes total 10 kWh. per 1 lb. of aluminium reduced from alumina). In most cases this has meant hydro-electric power. The advent of nuclear power, when it becomes available at a competitive price, may completely change the pattern of aluminium production. Power availability will no longer determine the locality of treatment. Power will be of a similar degree of importance, as an item of cost, to freights, water-supply, and alumina, and other raw materials.

Production will become possible close to the deposits, but this in turn may mean that deposits of local clays may provide the basis of some production close to large aluminium-consuming centres—such suitable clays may not be so abundant as some may anticipate at first thought and in any case this possibility will be determined by the interplay of the many items which constitute the cost of placing aluminium metal on the market. A picture emerges of a widespread industry with characteristics in part similar to the iron and steel industry and in part similar to non-ferrous metals. The northern Australian deposits are likely to prove well situated to enter this highly competitive market. Australian political stability may, in this international investment field, be a decisive factor.

Theory of Ore Genesis

In *Economic Geology* for November last a paper by C. L. Knight is entitled "Ore Genesis—The Source Bed Concept." The author says that after a good deal of searching in Australia for lead-zinc ore prior to **1950** it seemed to him that so many factors could be suspected of affecting ore localization of any individual ore-body that the fundamental problems of ore genesis could not be solved by work, no matter how detailed, on any one of them and that a better approach would be to examine the essential features of a large number of them and to find out which features were common factors. He had become dissatisfied with the popular theory—that the majority of ore-bodies had a magmatic origin and developed by a process of fractionation from the magma—largely because the theory was of no use in the practical business of finding new ore-bodies. His dissatisfaction deepened, he says, as it became apparent that the theory did not even fit the facts in many important instances. In several fields in Australia, where granite out-cropped and the ore-bodies were of the shear type, genetic linkage of granite and ore did seem to be a reasonable assumption. However, in the four major lead-zinc fields of Australia—namely, Broken Hill, Mount Isa, Rosebery, and Lake George—the linkage of ore with intrusives was not at all obvious and it was necessary to suppose that the parent magma in each case lay at considerable depth. On the other hand, in each of these fields, the importance of a particular sedimentary bed in localizing ore was obvious and the same feature was observed in several less important fields.

During **1950** and **1951** the author visited many mining fields in Africa and Europe and noted that stratigraphy was the fundamental ore control in several fields. Moreover the principle of stratigraphic control was being used with success in Northern Rhodesia and the Belgian Congo in the search for new ore. This relationship between stratigraphy and ore is common to several large and highly important fields and must be accounted for by any acceptable theory of ore genesis.

He then gives a *résumé* of conditions in various fields, going on to say that those described are examples of fields in which ore-bodies are confined, through each field, to a single formation or to a thin group of formations. Stratigraphic control of ore location is, then, he concludes, a feature common to several important mining fields and operative in most of them over areas of hundreds of square miles and in several over areas of thousands of square miles. This important, and common, feature of stratigraphic control must, he says, be accounted for by any acceptable theory of ore genesis.

Two opposing theories of ore genesis are under discussion at the present time—the *epigenetic* theory that metal sulphides were introduced by fluids that originated in some body external to the host rock and the *syngenetic* theory that the sulphides were deposited in their present position as original sedimentary components. The epigenetic theory states that the source of the sulphides was a granitic or basaltic magma, an ore magma, or a granitized block of sediments. Apart from the lack of outcropping intrusives or granitized masses in many of the fields listed in the paper the common emplacement of sulphides at one stratigraphic horizon presents a great obstacle to acceptance of the popular hydrothermal epigenetic theory. It must be supposed that ore fluids entered the sediments from outside, permeated very large blocks of sediments, and deposited sulphides in only one formation of the sedimentary succession, leaving no trace of its passage through the other formations. It seems inconceivable that such an extremely selective process could have operated over the thousands of square miles involved in the Kupferschiefer copper-lead-zinc field, the Northern Rhodesian copperfield, and the Belgian Congo copper-cobalt field, and scarcely less conceivable for the other fields. If the ore-bearing bed were invariably the one rock type, the author says, it might be argued that chemical properties peculiar to the bed were responsible for its favourability to ore replacement. This however is not the case. Each of the common sedimentary rocks with the exception of greywacke—namely, shale, siltstone, sandstone, conglomerate, limestone, dolomite, and marl—comprises the ore-bearing bed in different fields.

The author finds the popular epigenetic theory unacceptable for these fields. On the other hand in some of the fields listed—for example Broken Hill, Mount Isa, and Morocco—some measure of control of the shape of ore-shoots by structure has been proved beyond reasonable doubt and a simple syngenetic origin is therefore untenable. If the sulphides of these ore-bodies were deposited originally as primary sedimentary components of the bed, they must have migrated appreciable distances within the bed at some subsequent time. Moreover, it is suggested, it seems illogical to assume a sedimentary origin for one sulphide ore-body and to argue that another ore-body of very nearly identical mineralogy originated from a magma. If the ore-bodies of the fields listed in the paper are basically sedimentary in origin, he says, then it is logical to argue that all sulphide ore-bodies, with the possible exception of some magmatic segregations, were derived from original sedimentary accumulations of sulphides and that subsequent

migration of the sulphides was a common event and varied only in degree in different fields.

It seems to the author that the large degree of stratigraphic control of ore-bodies evident in many important fields cannot be explained in terms of the popular epigenetic theory. The simple form of the syngenetic theory is also inadequate as it does not take into account the fact that the shape of ore-bodies is controlled in many instances by post-sedimentation structures. The author proposes the *Source Bed Concept* that sulphide ore-bodies in the great majority of mining fields are, or were, derived from sulphide accumulations that were deposited contemporaneously with other sedimentary components at one particular horizon in the sedimentary basin which constitutes the field and that the sulphides subsequently migrated in varying degree under the influence of rise in temperature of the rock environment. The two most important causes of rise in temperature would be deep burial, resulting in strong metamorphism or granitization, and granite intrusion. Where a field is characterized by neither strong metamorphism nor granite intrusion, as is the case in the majority of fields listed in this paper, the original stratigraphic control would be clearly in evidence.

A study made of the stratigraphic associations of the lead-zinc deposits of all types described in Vol. XVIII of the International Geological Congress of 1948 showed that detailed stratigraphic environment is described for only a few of the deposits, but, of the 108 for which country rock is cited, 56 are actually in limestone or dolomite and a further 7 have these rocks in the immediate vicinity. This seemed to be out of all proportion to the percentage of carbonate rock in the earth's crust and suggested that lead-zinc ores at least were found only in a particular sedimentary environment. The author thought that this environment was similar to the environment under which evaporite deposits formed. Condon and Walpole have since interpreted the environment of the uranium deposits of the Rum Jungle-South Alligator River field as edge-of-shelf sediments and they suggest that the edges of shelves in geosynclinal basins may be favourable loci for the bio-chemical precipitation of sulphides.

Mount Isa Copper Smelter

A paper by the smelter staff appearing in the *Proceedings* of the Australasian Institute of Mining and Metallurgy for September, 1957 (No. 183) describes "Operations at the Mount Isa Copper Smelter." The new plant came into operation on February 6, 1953, the general layout and equipment following well-established practice. However, the choice of site for the smelter was limited by the necessity for close proximity of the waste-heat boilers to the power-house. Much excavation was necessary before foundation work commenced, but the plant is compact and further expansion is possible.

Roaster charge initially comprised concentrates, purchased ores, revert materials, mine sulphide ore, and barren sand, but as purchased ore receipts increased and domestic "black-rock" oxidized ore became available, the latter two fluxes were eliminated from the charge. Fluxes at *minus* $\frac{3}{8}$-in. sizing are trucked from crushing plant or stockpile by motor lorries. Filtered mill concentrates are dropped from an overhead conveyor on to the storage patio floor adjacent to the two concentrate bins. The charge is proportioned from eight storage bins on to a single collector belt and conveyed to feed storage bins, one above each roaster. Six bins are used for fluxes and two for concentrates.

The original design provided for handling the concentrate by Eimco electric shovels from storage on the patio floor along a level run into the bins below floor level, but the working properties of the concentrates were not as anticipated. Moisture content was high and concentrates were either sloppy and sticky, or dry and cemented, in which state they would assume a vertical angle of repose. The Eimco shovels were not suited to this work and consequently speed was slow and maintenance excessive. They were replaced by a D-4 bulldozer, pushing the concentrates into the bins. A further difficulty was encountered, in that concentrates could only be made to flow through bins by barring down by hand. This problem was overcome by widening the discharge belts from 24 in. to 48 in. and widening the bins to suit.

Roasting equipment comprises two Garfield-type 8-hearth roasters. Calcines are discharged to two hoppers under each roaster and conveyed by calcine car along a straight run of track to the furnace Wagstaff gun dust-tight connexions. Discharge of calcines and dust from the roaster hoppers above the calcine car is by means of a horizontal slide gate under each hopper. These were originally operated by a lever arrangement requiring considerable effort to operate and leakage occurred even when the slides were hammered shut. Air cylinders were fitted in place of the hand levers, resulting in cleaner, safer, and easier operation. To prevent dusting and spillage the calcine car and the transfer points are vented by a fan and flue system discharging into the roaster balloon flue.

Soon after production began the roasters became a bottleneck owing to insufficient transport capacity on the hearths, particularly the top deck which became overloaded with wet feed. This was rectified by providing a hole 18 in. by 12 in. through the first hearth immediately below the feed inlet and above part of the drophole between the second and third hearths. The feed entering the roaster was then distributed over the top three hearths, relieving the loading and affording better opportunity for drying. On the lower hearths (5, 6, and 7) 6-in. and 7-in. rabble blades were replaced by 12-in. blades. Since these changes were instituted each roaster is capable of transporting up to 250 tons per day without imposing undue strain on the drive.

Roaster hearths are ploughed, scraped, and a layer of iron oxide run on to the hearths whenever this becomes necessary. When production is at a high rate or roasters are being fired hard to maintain a high matte grade ploughing is done at three-weekly intervals, an operation taking 16–20 hours. Each roaster is equipped with a Major S-32 oil burner on the 4th, 6th, and 8th hearth. These are for ignition and control. Roasting is almost autogenous, fuel consumption being 1·3 gal./ton feed.

Although the roasters have done a remarkable job, it was recognized that insufficient roasting

capacity, by limiting matte grade, is restricting converter output and therefore a third roaster is under construction.

Reverberatory Smelting

Reverberatory furnace operation follows general practice at American Smelting and Refining copper plants. The furnace inside dimensions are 20 ft. wide and 90 ft. long at the bath level, with 20-in. sprung silica arch and flat suspended uptake roof of silica. It is charged through retractable water-cooled Wagstaff gun feeders, one on each side of the furnace. Converter slag is returned *via* a water-cooled cast-iron launder through the curtain wall. Reverberatory slag is skimmed through a water-cooled copper skim block in the sidewall at the discharge end of the furnace and granulated by high-pressure water.

Under normal operating conditions the matte bath depth is 20 in. to 24 in. and the total depth of matte *plus* slag is 36 in. to 41 in. Reverberatory slag averages 37·7% Fe and 38·7% SiO_2. Contrary to experience at many smelters magnetite has never been a problem. There has been no change in level of the furnace bottom.

Pulverized coal at 85% *minus* 200-mesh sizing, together with primary air, is piped direct from any one of the three mills to four 8-in. burners. Combustion air is pre-heated in heat exchangers at the exit of the boilers and a split is taken to the mills as primary air, the remainder being added as secondary air at the burners. Combustion control is rendered almost completely automatic by recording and controlling instruments having the following functions: (*a*) To maintain a set weight ratio of coal to primary air; (*b*) to maintain a set temperature of the coal-air mixture; (*c*) to maintain a set firing rate by control of the volume of coal-primary air mixture, and (*d*) to maintain a set furnace draught. In addition a recording radiation pyrometer indicates furnace temperature. Normally secondary air is at 400° F., coal primary air 150° F. at mill outlet, and furnace draft at 0·045 in. w.g. Adjustment of firing rate and secondary air is made by the furnaceman to suit furnace requirements.

The pulverized fuel system has given good service, particularly when running on one grade of coal. Combustion was unstable during the early months due mainly to unsuitable coal. It was found that fine coal, if moist or wet, blocked in the chute or the feed table and that coal too large likewise caused blockages. Poorly mixed blends of coal requiring differing coal-air ratios and having different grindabilities also caused combustion difficulties. Good combustion conditions are obtained with a coal having a calorific value of 12,500 B.Th.U./lb. and an ash content of 12·5%. Higher ash content requires more frequent cleaning of furnace uptakes.

The height of the burners was decreased in several stages from 5 ft. 9 in. to 4 ft. 8 in. above the furnace bottom. The results of this are not conclusive, but it is interesting to note that the first reduction of 9 in. was accompanied by improved combustion control, possibly due to increased fall-out of ash on the bath and the lower hot portion of the uptakes.

Although the furnace has been cooled down and brickwork repairs effected at yearly intervals in no case was the shut-down imperative, the decision to carry out repairs being influenced by factors external to the smelter. At the second shut-down 30 ft. of arch in the combustion zones was replaced as the minimum thickness was 3½ in.

The line of attack on the problem of increasing brick life has been to protect the brick by continuous silica spraying and by improving furnace sidewall air cooling. The silica grinding plant was not ready for use when operations began. Three weeks after start-up a section of the reverberatory furnace sidewall collapsed from being undercut at the slag line. After repairs a programme of daily spraying of silica slurry was commenced. Each day the coal burners are turned off and the furnace interior is inspected by a metallurgist, furnace foreman, and slurryman. Approximately 100 tons per month of pure quartz ground to 80% *minus* 200 mesh is applied to the furnace brickwork. The slurry is mixed at 65% solids to which is added 2% by weight of bentonite.

To provide better cooling the thickness of the brickwork in the sidewalls was reduced in overheated areas. A slot four courses high was formed along the sidewalls from the level of the top course of the magnesite crucible. In the combustion zone this slot is air-cooled and dead-burned magnesite used. This arrangement has proved very successful and is considered to be cheaper and safer than water-jacketting.

Matte Tapping

The matte tapping block is cast from green blister copper in a steel mould containing the 9 in. by 9 in. by 9 in. magnesite cored block *in situ*. Being cheap these are expendable and are changed every seven days regardless of condition to avoid costly runaways. Although the cast-iron matte launders of the original design gave good service they were replaced by a launder formed from a trench in the floor and lined with silicious ore. This avoided replacement in the event of matte runaways. It was also found that the silica launder could be more readily cleaned and repaired between converter cycles.

The system of slag granulation as designed and installed was not well suited to the job and was particularly dangerous if operated incorrectly. Two jets were used, one for granulation, the other for flushing and cooling. The bottom of the granulated-slag launder, along which the flushing water flowed, was 4 ft. below the slag launder. Minor blockages could not be cleared quickly and became major blockages with consequent danger of explosion. Alterations to the design have necessarily been cautious and it is only in the last six months that the final step has been taken. The system now uses a granulating jet only, consisting of a 10-in. pipe blanked off and perforated with ⅝-in. holes. The jet is set at the bottom of the granulated-slag launder, the bottom of which is 17 in. below the molten-slag launder. The pepperpot jet replaces earlier single horizontal slot-type jets, its success being due to the fact that the stream is immediately broken up so that it is impossible for molten slag to get through the depth of the jet and cause blockages at the point where it strikes the launder below.

Slag disposal continues to be a problem, as fine slag particles overflow the settling tanks into the main cooling pond and quickly fill it. Some measure of control is exercised by dredging with a pontoon-mounted pump, but it has been found necessary to clean out the main pond each time the furnace is shut down for repairs.

Recently full-scale tests were carried out to determine whether the addition of limestone to the furnace charge would effect smelting economies. The plant was run for alternate four-week periods with and without limestone. It was shown that limestone to the extent of 5% on the roaster feed had the following effects : (1) Gave improved bath conditions and faster smelting rate ; (2) reduced the fuel ratio from 4·0 to 3·5 million B.Th.U. per long ton solid charge ; (3) reduced the copper content of reverberatory slag from 0·42 to 0·38% Cu by reason of higher SiO_2 and lower Fe in the slag and uniformly good bath conditions, and (4) enabled smelting of a higher tonnage of custom ores and domestic oxidized ore.

Converting

The converting section comprises two 10 ft. by 20 ft. Pierce-Smith converters serviced by two 40-ton overhead travelling cranes each equipped with two 20-ton hooks. Converter air is supplied by one of two Ingersoll Rand steam turbo-blowers rated at 14,000 cu. ft./min. free air at 14 p.s.i.g. There are 32-1½-in. tuyères at 6-in. centres entering the shell 4½ in. below the horizontal centre line and pitched 1 3/16 in. in 12 in. Tuyères are hand punched, using ¾-in. hexagon bar upset to 1 3/16 in. Reaming is also done by hand, using a ⅞-in. drill steel upset to 1⅜ in. Each puncher platform is adjustable for height by four screw jacks driven by an electric motor. Average blowing rate is approximately 9,600 cu. ft./min. free air. Pressure at the tuyère manifold averages 10·5 p.s.i.g. Air consumption averages 50,000 cu. ft. per min. per ton matte converted.

Converting capacity being a limiting factor on maximum smelter output much attention has been given to establishing a suitable converting procedure and several modifications were made with notable success.

Knob Lake Iron

"The Knob Lake Iron Ore Deposits" are described by R. D. Westervelt in a paper published in the *Canadian Mining and Metallurgical Bulletin* for November last. In this part of Canada the iron formation is contained in a belt of rocks which extends northwards from the south-west corner of Labrador to Cape Hopes Advance at the north-west tip of Ungava bay, a distance of some 600 miles. The belt, commonly referred to as the "Labrador Trough," is made up of a geological unit of folded and faulted sedimentary and volcanic rocks. At the central part of the "trough" the belt is about 60 miles wide. It tapers to a width of 12 miles as exposed on the northern extremity ; to the southward it thins out, divides into two strips, showing increased metamorphism, and is eventually lost under the numerous lakes in the region.

The deposits are described as zones of enrichment occurring in the Sokoman iron formation. They are mostly elongated bodies lying generally parallel with the regional strike and with great variation in size and depth. Most of them are shallow and can be mined out entirely by open-pit methods. Many of the bodies occur along or near the north-easterly-dipping thrust faults, especially where there is a sharp syncline in the rocks along the fault. They are distinctly wider where cross-faults intersect them.

Ore-bodies normally occur in structural troughs formed by the intersection of folded strata and a fault or in synclines. Some deposits occur in homoclines, however, and appear to be unrelated to broad structure. The concentration of iron ore from iron formation by meteoric waters is the most applicable and widely held hypothesis. The process involves the oxidation of ferrous iron, some hydration, the leaching out of large quantities of silica, and the probable introduction of goethite replacing the silica.

In 1952 drilling operations on an ore deposit of the trough revealed a section of brown coal buried at a depth of more than 150 ft. ; iron ore lay above and below the coal. Thin section analyses confirmed the plant nature of the material and showed it to be of coniferous origin and suggesting Mesozoic or Tertiary age. The relation of the coal to the iron ore is uncertain because of the unknown structural pattern within the ore deposit ; it may be folded or faulted into the iron ore, or it may be an exceedingly large crevasse filling. Should the former prove to be the case, evidence of late Mesozoic or Cenozoic tectonism within the Labrador Trough is indicated.

The deposits may be described as a mixture of haematite and goethite. However, deposits containing haematite alone are known, and others in which the ore is either goethite or limonite alone. The character of any one deposit can change very rapidly from predominantly haematite to goethite, or to a mixture of all or any two of the three main ore minerals. For these reasons it is very difficult to set up a suitable classification of the deposits. They may, however, be classed in three groups according to their chemical composition. Bessemer and non-Bessemer grades containing respectively less and more than 0·045% phosphorus and manganiferous ores containing more than 3% manganese. The known ore reserves, approximately 420,000,000 long tons, are about 60% Bessemer ore, 30% non-Bessemer ore, and 10% manganiferous ore.

If the ore-bodies are classified according to their physical appearance there are again three main types, although these do not correspond with the chemical types. The majority of the ore is "brown ore" consisting essentially of goethite with minor haematite and soft limonite. The highest grade ore is "blue ore" consisting of haematite, with goethite, limonite, and minor magnetite. Yellow limonite ore is relatively unimportant. The presence of manganese generally imparts a darker colour to the ore.

Most of the blue ores are Bessemer grade, but so also is much of the brown ore. The brown ores form mainly in the silicate-carbonate iron formation while the blue ores occur in the cherty metallic iron formation. Since most of the non-Bessemer and

manganiferous ores are found in the silicate-carbonate iron formation, their higher phosphorus content is probably due to original phosphatic sediments within it. The manganese was probably brought in by ground water. Manganese minerals have been observed as nodules associated with early limonite in solution cavities.

The physical character of the ore varies from hard and compact to soft and porous, but may be described as mainly friable. The porosity ranges from 16·6 to 29·6%, averaging 22·8%. Generally speaking, the porosity of these ores is greater than that of other common iron ores (20·5% Mesabi, 16·7% Steep Rock, 10·6% Marquette). This is desirable to a certain extent since, as the porosity increases, the ease of reducing the ore in the furnace increases.

The ore contains no iron carbonates or silicates, the main ore minerals being haematite and goethite with accessory magnetite and limonite. Silica is present as crystallized chert and secondary quartz veining the ore.

Summarizing, the author says that much of the iron formation is oxidized and leached but all the members, except possibly the jaspillite, have been traced to unaltered equivalents. The early iron minerals were associated with cryptocrystalline chert and were predominantly ferrous minerals—magnetite, minnesotaite, siderite, minor haematite, and stilpnomelane. It is thought that the chert and most of the carbonate are primary precipitates. Minnesotaite and stilpnomelane formed as gels by direct precipitation or by diagenesis in the unconsolidated material, although stilpnomelane may be a product of metamorphism of a shaly member. Some of the haematite is undoubtedly primary and, although it appears that some magnetite may have been precipitated directly, most of it is believed to have formed diagenetically by the reduction of precipitated ferric hydroxide.

The iron formation is part of a marine assemblage and is believed to have collected in a restricted marine basin. Most of the iron and silica were probably derived from weathering of an old land surface and organic matter provided protective colloids to bring them to the basin of deposition and also maintained reducing conditions in the area of deposition. The iron may have come out of solution as ferric hydroxide, being later reduced, or it may have been precipitated directly as a ferrous silicate or carbonate. The oxidized and leached iron formation is characterized by recrystallized chert and pseudomorphs of haematite and goethite after magnetite, carbonates, and silicates. The alteration began by the leaching and alteration of the carbonates to goethite, then the silicates were altered to goethite, and magnetite was partly altered to martite. Increasing recrystallization of the chert and the partial leaching and replacement of goethite were accompanied by the alteration of magnetite to complex grains of martite and limonite and by the development of a selvage of haematite on pseudomorphs of goethite after carbonates. In enriched zones and in ores the chert is coarsely crystalline and mostly replaced by goethite or leached, while the pseudomorphs have been transformed to haematite ; it is thought that weathering and circulating solutions were capable of altering the iron formation to its present state. The silicate-carbonate iron formation is the most favourable ore-producing member since its components are quite easily altered.

Trade Paragraphs

Matthew Brothers, of Sandy Lane North, Wallington, Surrey, release some details of an equal four-wheel-drive loading shovel with a bucket capacity of 1¼ cu. yd. and torque converter transmission.

North British Rubber Co., Ltd., of Castle Mills, Edinburgh, call attention to progress being made in extensions to their factory buildings to be largely used for a range of hose which they manufacture and including giant oil hose which is now an important export item. The foundations were recently laid by the Lord Provost of Edinburgh.

Megator Pumps and Compressors, Ltd., of 43, Berkeley Square, London, W. 1, have formed a subsidiary company in the U.S.A. to handle their American business in industrial self-priming pumps. The new company, known as Megator Pumps and Compressors Inc., has headquarters at 930, Manchester Avenue, Pittsburgh, Pennsylvania.

Mobil Oil Co., Ltd., of Caxton House, Westminster, London, S.W. 1, in their latest *Industrial Technical Bulletin* give some particulars of fire-resistant water-base hydraulic fluids, which are available in two viscosities to meet the requirements of most hydraulic systems. As long as the water content of the fluids has not evaporated they can be considered as non-inflammable.

Hadfields, Ltd., of Sheffield, have published a leaflet giving particulars of their pneumatic mine car retarder, which is specially designed for reducing the speed of fast-moving cars without any manual control. It is simply bolted down on the track where required to operate and is not dependent on any external supply of compressed air. Cars can be allowed to run into the retarder singly or in numbers but will only be released one at a time at a predetermined speed for which the device has been set. Another leaflet recently issued gives details of a variety of precision steel castings in unusual or complex shapes, designed to eliminate or reduce subsequent machining.

British Ropes, Ltd., of Doncaster, announce that they have just commenced a new service to rope users in the Federation of Malaya, based on their marine depot at Keppel Harbour, Singapore, which was opened earlier this year. It provides on-the-spot facilities for splicing, terminal fitting, and the make-up of slings for marine and industrial uses. Among the stock of rope at the Keppel Harbour depot are special tropicalized steel wire ropes—the product of research by the company into the problems of rope preservation in extreme tropical conditions. This new arrangement is purely a service to users in the Federation of Malaya and neighbouring countries. Messrs. Paterson, Simons and Co. Ltd., remain responsible for sales.

Ferodo, Ltd., of Chapel-en-le-Frith, Stockport, are now marketing a new woven asbestos friction material which has been specially developed for certain industrial and mining applications such as winding and haulage gear where high temperatures and arduous working conditions are encountered and comparatively soft brake paths are in use. In the course of its development extensive field tests have shown that the material, which has a zinc wire inclusion, has a stable coefficient of friction of 0·38 to 0·4 and is suitable for use where temperatures up to 572° F. are encountered. A further notable characteristic is its relatively high degree

of flexibility, which not only helps eliminate squeal and judder in plant prone to these complaints but also allows it to be easily formed to radius on the site without using special tools.

Head Wrightson and Company S.A. (Pty), Ltd., of Johannesburg, have been awarded a contract for the supply of a 16 ft. diameter blast-furnace which is part of the expansion programme now launched by the Rhodesian Iron and Steel Co. (Pvt.), Ltd., for its works near Que Que, Southern Rhodesia. In addition the same company have secured the order for a 3,000,000 c.f.h. gas cleaning plant for the new furnace and two smaller existing furnaces. The plant will be to the general design of Head Wrightson Iron and Steel Works Engineering, Ltd., a subsidiary of Head Wrightson and Co., Ltd., in collaboration with the Rhodesian Iron and Steel Co's consulting engineers, Messrs. John Miles and Partners, of Bulawayo. The charge will consist of a blend of primary ore and sinter and the coke will be produced on the works site from Wankie coal.

F. E. Weatherill, Ltd., of Welwyn Garden City, Herts., state that torque converter transmission is now available for their hydraulic mobile loading shovel range as an alternative to the normal clutch gearbox, the Brockhouse unit being employed. They point out that basically the transmission provides within a certain speed range an infinitely variable gear which automatically adjusts itself to load requirements. So far as the shovelling action is concerned the availability of increased torque greatly improves the penetrating power, minimizes stalling of the engine, and reduces any risk of damaging the transmission and final drive. A high starting torque is also a feature of the converter and this is conducive to smooth take up of the drive and quick acceleration. Shock loads to the engine are prevented, due to the cushioning effect of the fluid drive. Two forward speeds and one reverse are provided.

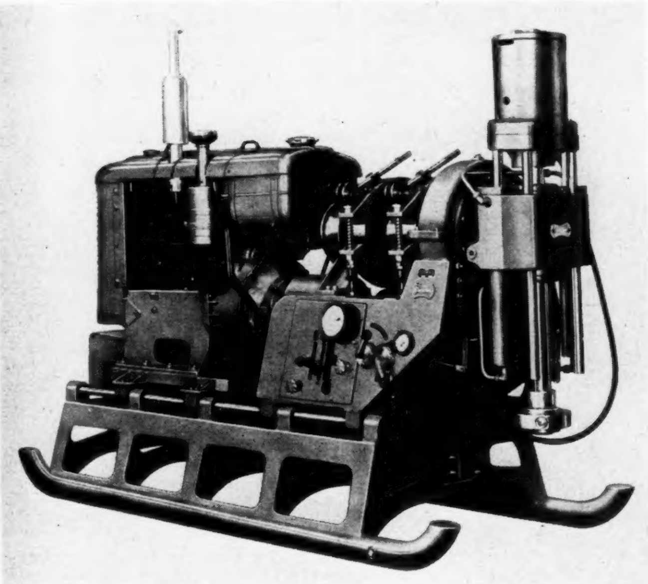
Belmos Co., Ltd., of Bellshill, Lanarkshire, have recently introduced a new gate-end box designed to comply with the latest N.C.B. specification. Rated at 150 amps and suitable for use on a.c. systems up to 650 volts the unit comprises a two-compartment welded-steel enclosure, one compartment housing the contactor, protective, and relay equipment and the other the isolating switch. The contactor, overcurrent, and control relays, voltage and current transformers, etc. are mounted on a removable chassis with plug-in connexions for main and auxiliary terminals and no bolts or screwed fixings are used, thus enabling the chassis to be removed for inspection without the use of tools. The isolating switch is of the load breaking type and will handle current values of 1,200 amps. at 650 volts 0·25 power factor, equivalent to the stalling current of the largest motor likely to be associated with the box.

Lister Blackstone Rail Traction, Ltd., of Imperial House, 15–19, Kingsway, London, W.C. 2, is the title of a subsidiary company formed to handle the rail traction application of Lister and Blackstone diesel engines and other equipment manufactured by **R. A. Lister and Co., Ltd.,** of Dursley, and **Blackstone and Co., Ltd.,** of Stamford. The Lister rail truck has been used extensively on industrial sites and other duties all over the world. They are now being supplied with Lister air-cooled diesel engines. These engines have been fitted in many low-powered industrial type narrow-gauge works locomotives and are extensively in use overseas. At the upper end of the locomotive power range available from the new company the Lister-Blackstone ERT series of engines has been extended by the development of a twin-bank version with fabricated base and cylinder housings. These are available as 12 and 16 cylinder units with crankshaft speeds of 800 r.p.m., built-in gearboxes, and output shaft speeds up to 1,250 r.p.m.

Consolidated Pneumatic Tool Co., Ltd., of 232, Dawes Road, London, S.W. 6, have introduced a new piece of equipment to deal with the fitting and renewal of connexions to hosepipes. The equipment consists of a $2\frac{1}{8}$ in. diameter single-acting spring-return cylinder with a 3 in. stroke piston, the cylinder being mounted on a baseplate with a hose clamping vice facing the cylinder and piston and mounted on the same baseplate. The two jaws of the vice are fitted with removable inserts to accommodate different diameters of hosepipe. Air control is achieved through a single-acting hand-operated valve to which is fitted an air-flow regulator. Sleeves are supplied for the piston rod to suit various types of hose fittings. Operation of the unit consists of gripping the hosepipe in the vice, fitting a hose connexion to the piston rod, and operating the air valve. Fitting is thus carried out in a moment and experience has shown that a connexion can be adequately pressed home even in a high-pressure reinforced hydraulic hose.

Quasi-Arc, Ltd., of Bilston, Staffs., state that a new diesel engine-driven arc-welding set has been added to their range. Known as Type DEB.400U, the set has quick voltage recovery and is particularly suitable for depositing the cellulose-covered types of electrode frequently used in positional pipe welding. It also has a particular application for work on remote sites where mains electricity is not available. It gives stable arc conditions when used for pipe welding with Quasi-Arc Celtian electrode and with all other ferrous and non-ferrous types. Field excitation of the welding generator is obtained from a separate belt-driven generator of standard manufacture as used on many commercial vehicles. The generator is flange-coupled to a Ford four-cylinder water-cooled industrial diesel engine, with electric starting and a heavy flywheel to ensure satisfactory emergency hand-starting, the unit being rated at 40 b.h.p. at 1,500 r.p.m. at sea-level and 60° F. ambient temperature. A feature of the set is the fully automatic idling device. Pneumatically operated it is arranged to reduce the engine to idling speed automatically when welding is not in progress. Another feature is that the controls are arranged to give the operator the choice of a large number of volt-amp. characteristics, so that he can adjust the welding conditions to suit the job in hand. The equipment is normally mounted on a four-wheeled pneumatic-tyred undergear for hand towing, the two front wheels being steerable and attached to a draw-bar. It is also available mounted on brackets for stationary use or on a 2 or 4-wheeled road-towing undergear.

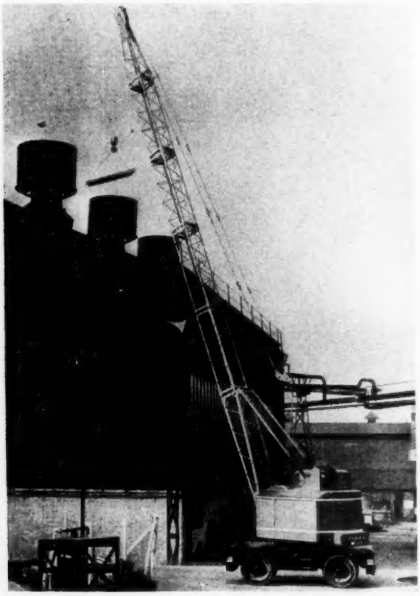
Craelius Co., Ltd., of 12, Clarges Street, London, W. 1, make available some particulars of the XH-60 and XH-90 diamond core drill, a catalogue of which has been published by Svenska Diamantbergborrnings AB, of Stockholm. In metric standards these drills are suitable for rods of 42 mm., 50 mm., and 60 mm. and depths of 200 to 600 metres according to the diameter of the hole, the data being for



Craelius XH-60 Diamond Core Drill.

medium-hard rock. The XH-60 is illustrated here. The XH-60 and XH-90 are suitable for drilling in all formations in all directions underground or from the surface. The spindle heads on the XH-60 and XH-90 drills are designed for drilling with drill rods and casing strings of several sizes ; the XH-60 has a spindle inner diameter of 66 mm. and the XH-90 an inner diameter of 91 mm. The hydraulic chuck is suitable for both external flush and external upset drill rods. It instantaneously releases or grips the drill rods, which are automatically centred during the drilling. The engine is directly connected to the drive shaft of the drill. The grouping of the indicators and operation levers on the same panel gives the operator quick and efficient control of the drilling progress. To facilitate transport in difficult terrain the drill can be broken down into seven main parts, the heaviest part weighing 490 kg. The pressure on the drill bit is easily adjustable from the spindle head when either the light weight of the drill string or the direction requires an increased pressure, or the heavy weight of the drill rods is to be counterbalanced. The bit pressure and the drill rod weight are indicated on a differential pressure gauge which gives exact values. The hydraulic system, including a high-pressure oil pump, makes it possible to effect these operations with few and simple movements and with great accuracy. The following operations are effected hydraulically :—The feed and return of the spindle, the retraction of the drill and engine from the drilling position when hoisting and lowering the drill rods, and the opening and closing of the hydraulic chuck. The Craelius adjustable derrick (12·5 m., 10·5 tons) is recommended for use with both drills. The Craelius KSP 90 by 75 flush pump is supplied as standard equipment. This pump is designed for both clear water and mud flush. For larger flush capacity the Craelius KSP 100 by 150 is recommended.

George Cohen 600 Group, Ltd., of Wood Lane, London, W. 12, recently demonstrated the new Jones KL 10–6 mobile crane, as illustrated here. This new model in the range has been introduced to help meet the increasing demand for a 10 ton capacity machine, already met in part by the Jones KL 10–10 " Fast Travel " crane introduced earlier in 1957. It is a robustly built, diesel-powered, fully-slewing machine, employing direct mechanical drive and available on a range of chassis. Power from the Perkins engine is transmitted through a 3-speed gearbox and triplex roller chain drive and thence, by means of separate dry-plate clutches, to the four crane motions. The full power of the engine is thus available to each of these motions, which can be operated independently or in any desired combination. The mechanism for each motion—derricking, slewing, hoisting, and travelling—is arranged in the form of a separate self-contained unit, with all gearing totally enclosed. This unit construction principle means that complete units may be interchanged quickly and simply. At the same time standardization of parts, both within the mechanism of the one machine and between models, has been achieved wherever possible. Drive to the wheels is through a 4-wheel differential which makes wheel spin impossible and gives the crane crawler performance on soft ground while preserving the speed characteristics of the wheeled chassis when on level going. The steering is progressively power assisted and automatically corrected so that the action is normal whatever the position of the superstructure. There is a special designed arrangement by which the lowering is accurately and smoothly controlled by governor



mechanism (standard) or by an auxiliary power-lowering drive from the crane engine. Full-circle slewing in both directions is provided for, the superstructure being mounted on large-diameter ball bearings and located by hook rollers. The standard jib is of the sectional, lattice-construction, strut type, the basic length being 30 ft. Additional 10-ft. sections can be added up to a total of four, the maximum working length being 70 ft. Where additional height or outreach is required a jury mast can be fitted, while special jibs of the swan-neck or other types are available.

RECENT PATENTS PUBLISHED

☛A copy of the specification of the patents mentioned in this column can be obtained by sending 2s. 8d. to the Patent Office, Southampton Buildings, Chancery Lane, London, W.C. 2, with a note of the number and year of the patent.

15,795 of 1945 (786,883). N. C. BEESE. Method of purifying uranium.

26,586 of 1952 (787,630). BERGWERKSVERBAND ZUR VERVERTUNG VON SCHUTZRECHTEN DER KOHLENTECHNIK GES. Froth flotation process.

23,778 of 1954 (787,027). N. MATHESON. Borehole pump installations.

3,548, 19,240, and 23,203 of 1955 (788,174, 788,308, and 788,309). IMPERIAL CHEMICAL INDUSTRIES, LTD. Manufacture of titanium.

6,348 of 1955 (788,006). PREPARATION INDUSTRIELLE DES COMBUSTIBLES. Processes for washing ore, coal, or other granular materials.

21,107 of 1955 (787,437). GUTEHOFFNUNGSHÜTTE STERKRADE A.-G. Devices for feeding additions to metallic melts.

33,327 of 1955 (787,778). COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION. Production of hafnium-free zirconium from crude sources of zirconium.

5,170 of 1956 (788,273). FAGERSTA BRUKS A.B. Drill devices for deep and long-hole drilling.

10,792 of 1956 (788,277). METALLGESELLSCHAFT A.-G. Method of increasing the ouput of sintering apparatus.

NEW BOOKS, PAMPHLETS, ETC.

☛Publications referred to under this heading can be obtained through the Technical Bookshop of *The Mining Magazine*, 482, Salisbury House, London, E.C. 2.

L'Industrie du Diamant en 1956. By A. MOYAR. Paper covers, 181 pages, illustrated. Brussels: Belgique Coloniale et Commerce International.

Mozambique : Legislação Mineira : (1) The Mining Laws for the Portuguese East Africa (Moçambique), (1905–1956). Paper covers, 111 pages. Lourenço Marques : Direcção dos Serviços de Geologia e Minas.

Bibliography of Titanium Deposits of the World. By R. LAWTHER and H. R. MARK. U.S. Geological Survey Bulletin 1019–G. Paper covers, pp. 543–608. Price 25 cents. Washington : Superintendent of Documents.

Selected Annotated Bibliography of the Geology of Sandstone-Type Uranium Deposits in the United States. By R. E. MELIN. U.S. Geological Survey Bulletin 1059–C. Paper covers, pp. 59–175. Price 35 cents. Washington : Superintendent of Documents.

Metal Statistics, 1947–1956 : On Aluminium, Lead, Copper, Zinc, Tin, Cadmium, Magnesium, Nickel, Mercury, and Silver (44th Annual Issue). Cloth, quarto, 234 pages. Frankfurt am Main : Metallgesellschaft A.-G.

Quin's Metal Handbook, 1956–57. Pocket size. 704 pages. Price 25s. London : Metal Information Bureau, Ltd.

Safety in Mines Research, 1956. Paper covers, 75 pages, illustrated. Price 4s. London : H.M. Stationery Office.

A Survey of the Natural Gas Industry in Canada during 1956. Mineral Resources Information Circular M.R. 24. By R. B. TOOMBS and R. A. SIMPSON. Paper covers, 49 pages typescript. Ottawa : Department of Mines and Technical Surveys.

A Survey of the Petroleum Industry in Canada during 1956. Mineral Resources Information Circular M.R. 23. By R. B. TOOMBS and R. A. SIMPSON. Paper covers, 80 pages typescript. Ottawa : Department of Mines and Technical Surveys.

British Guiana : Report on the Geological Survey Department for the Year 1956. Paper covers, 32 pages. Price 50 cents. Georgetown, Demerara : Geological Survey.

Soldering Aluminium. A.D.A. Information Bulletin 23. Paper covers, 35 pages, illustrated. Price 2s London : Aluminium Development Association.

Geological Survey of South Australia. Geological Atlas, 1-Mile Series. (1) Darke area ; (2) Arno. Adelaide : Department of Mines.

Selected Index to Current Literature

This section of the Mining Digest is intended to provide a systematic classification of a wide range of articles appearing in the contemporary technical Press, grouped under heads likely to appeal to the specialist.

* Article in the present issue of the MAGAZINE. † Article digested in the MAGAZINE.

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